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Hardware Requirements Document for the Human Research Facility Muscle Atrophy Research and Exercise System (MARES) Rack

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Hardware Requirements Document
for the
Human Research Facility
Muscle Atrophy Research and Exercise System
(MARES) Rack

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Hardware Requirements Document
for the
Human Research Facility
Muscle Atrophy Research and Exercise System
(MARES) Rack

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Preface

This Hardware Requirements Document (HRD) defines the minimum set of requirements for the Human Research Facility (HRF) Muscle Atrophy Research and Exercise System (MARES) Rack to be placed on the International Space Station (ISS). This document is under the control of the HRF Configuration Control Board (CCB).

HRF CCB Chair DATE

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

A	Ampere
AC	Alternating Current
ADP	Acceptance Data Package
amps	Amperes
APM	Attached Pressurized Module
Ar	Argon
ATT	Acceptance Thermal Test
AWG	American Wire Gauge
AVT	Acceptance Vibration Test
CAM	Centrifuge Accommodation Module
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CFU	Colony Forming Units
CIL	Critical Items List
cm	centimeters
CO2	Carbon Dioxide
COTS	Commercial-Off-the-Shelf
dB	Decibels
DC	Direct Current
deg	Degree
dia	diameter
DR	Discrepancy Report
DRD	Data Requirements Document
Dwg	Drawing
EEE	Electrical, Electronic, and Electromechanical
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPCE	Electrical Power Consuming Equipment
EPS	Electrical Power System
ESA	European Space Agency
ESD	Electrostatic Discharge
EVA	Extravehicular Activity
EWACS	Emergency Warning and Caution System
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
fc	footcandle
FDS	Fire Detection Support
FIAR	Failure Investigation Analysis Report
FMEA	Failure Modes and Effects Analysis
FSS	Fluid System Servicer
ft	feet

ACRONYMS AND ABBREVIATIONS (Cont'd)

g	Gravity
GCAR	Government Certification Approval Report
GFCI	Ground Fault Circuit Interrupter
GHz	Gigahertz
GN2	Gaseous Nitrogen
GPVP	Generic Payload Verification Plan
grms	gravity, root mean square
GSE	Ground Support Equipment
He	Helium
hr	Hour
HRD	Hardware Requirements Document
HRDL	High Rate Data Link
HRF	Human Research Facility
HRP	Human Research Program
Hz	Hertz
I/F	Interface
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronic Engineers
IMS	Inventory Management System
IMV	Intermodule Ventilation
in	inch
ISIS	International Subrack Interface Standards
ISPR	International Standard Payload Rack
ISS	International Space Station
IVA	Intravehicular Activity
JEM	Japanese Experiment Module
JSC	Johnson Space Center
kg	Kilogram
kHz	Kilohertz
kPa	KiloPascal
KSC	Kennedy Space Center
kW	Kilowatt
LAN	Local Area Network
lb	Pound
lbf	pounds force
LED	Light-Emitting Diode
LLIL	Limited Life Items List
LRDL	Low Rate Data Link
LSP	Launch/Stowage Plate

ACRONYMS AND ABBREVIATIONS (Cont'd)

m/s	Meters Per Second
mA	Milliamperes
MARES	Muscle Atrophy Research and Exercise System
max	Maximum
MHz	Megahertz
min	minute
mm	millimeter
mmHg	Millimeters of Mercury
MPLM	Mini Pressurized Logistics Module
MRDL	Medium Rate Data Link
ms	Milliseconds
msec	millisecond
MSFC	Marshall Space Flight Center
MUA	Material Usage Agreement
MΩ	megaohm
N	Newton (metric force measurement)
N/A	Not Applicable
N_2	Nitrogen
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NSTS	National Space Transportation System (Do not use—use SSP)
NTSC	National Television Standards Committee
O_2	Oxygen
Oct	Octave
ORU	Orbital Replacement Unit
oz	ounce
Pa	Pascal
PDA	Pre-Delivery Acceptance
PDB	Power Distribution Box
PDU	Power Distribution Unit
PFE	Portable Fire Extinguisher
PHTR	Packaging, Handling, and Transportation Records
PIA	Pre-Installation Acceptance
PIP	Power Interface Panel
PRD	Program Requirements Document
psi	pounds per square inch
psia	pounds per square inch absolute
PSRP	Payload Safety Review Panel
PUL	Portable Utility Light

ACRONYMS AND ABBREVIATIONS (Cont'd)

QAVT	Qualification for Acceptance Vibration Test
QD	Quick Disconnect
QTT	Qualification Thermal Test
QVA	Qualification Vibration Analysis
RHA	Rack Handling Adapter
RID	Rack Insertion Device
RMA	Rack Mounting Adapter
RMS	Rack Maintenance Switch
rms, RMS	Root Mean Square
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RS	Radiated Susceptibility
SD	Standard Deviation
sec	second
SEE	Single Event Effect
Si	Silicon
SIR	Standard Interface Rack
SOW	Statement of Work
SSPC	Solid State Power Controller
SSPF	Space Station Processing Facility
SUP	Standard Utility Panel
TBD	To Be Determined
TBE	Teledyne Brown Engineering
TBR	To Be Resolved
TCS	Thermal Control System
TM	Technical Memo
TPS	Task Performance Sheet
UIP	Utility Interface Panel
UOP	Utility Outlet Panel
US	United States
USL	U.S. Lab
V	Volts
V/m	Volts per meter
VC-S	Visibly Clean-Sensitive
Vdc, VDC	Volts Direct Current
VIF	Vibration Isolation Frame
Vrms	root-mean square voltage
WSTF	White Sands Test Facility

ACRONYMS AND ABBREVIATIONS (Cont'd)

º	Degree
ºC	Degrees Celsius
ºF	Degrees Fahrenheit
%	Percent
Ω	ohm
π	pi
μA	microampere
μsec, μs	Microsecond

1.0 SCOPE

This specification defines the Human Research Facility (HRF) program requirements for the HRF Muscle Atrophy Research and Exercise System (MARES) Rack. The HRF MARES Rack is a facility class payload that will be used to support the HRF.

The primary governing documents for the requirements levied in this document are LS-71000, Program Requirements Document for the Human Research Facility and SSP 57000, Pressurized Payloads Interface Requirements Document. Other requirements are derived from the experiment unique interface definition documents for the various items of HRF equipment.

The requirements in Sections 3, 4 and 5 of this document consist of a minimum set of constraints for the HRF MARES Rack hardware. Hardware Criticality is defined in the table in Section 3.2 of LS-71000.

The HRF Project Office is the controlling authority for this document. The HRF Configuration Control Board (CCB) or a delegated authority must approve any deviations from the requirements of this document.

2.0 APPLICABLE DOCUMENTS

The following applicable documents of the exact issue shown herein form a part of this specification to the extent specified herein. If a revision level or date is not cited, the latest version of the document should be used.

All specifications, standards, exhibits, drawings or other documents referenced in this specification are hereby incorporated as cited in the text of this document. Any updated revisions to documents specified herein shall be reviewed to determine the impact to the design. Changes to the design or this document shall only be made upon the direction of the HRF CCB.

2.1 DOCUMENTS

Document Number	Revision	Document Title
220G07455	C	Rack Handling Adapters - Upper Structure
220G07470	B	Rack Handling Adapters - MSFC Base Assembly
220G07475	C	Rack Handling Adapters - SSPF Base Assembly
220G07500	A	Rack Shipping Containers
683-10007	H	Fire Detection Assembly
FED-STD-595	B	Colors Used in Government Procurement
JPD 5335.1	C	Lyndon B. Johnson Space Center Quality Management System (QMS)
KHB 1700.7	C	Space Shuttle Payload Ground Safety Handbook
LS-71000	B	Program Requirements Document for the Human Research Facility
LS-71011	A	Acoustic Noise Control & Analysis Plan for Human Research Facility Payloads and Racks
LS-71016	A	Electromagnetic Compatibility Control Plan for the Human Research Facility
LS-71053-1	Issue 3 3	Hardware Requirements Document for the Muscle Atrophy Research and Exercise System (MARES) of the Human Research Facility
MARES-0000-SP-103-NTE	Issue 1	MARES-HRF Interface Specification
MIL-A-8625	9/93	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-PRF-19500	M	Performance Specification Semiconductor Devices, General Specification for

Document Number	Revision	Document Title
MIL-STD-810	F Ch. 2	Environmental Test Methods and Engineering Guidelines
MIL-STD-1686	C	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
NASA-STD-6001	02/98	Flammability, Odor, Offgassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
NASA TM 102179		Selection of Wires and Circuit Protective Devices for STS Orbiter Vehicle Payload Electrical Circuits
NHB 6000.1	D	Requirements for Packaging, Handling, and Transportation - Electronics Control Unit (ECU)
NSTS/ISS 13830	C Ch. 4	Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle and International Space Shuttle
NSTS-1700.7	B Ch. 14	Safety Policy and Requirements For Payloads Using the Space Transportation System
NSTS-1700.7 ISS Addendum	B Ch. 5	Safety Policy and Requirements For Payloads Using the International Space Station
NSTS/ISS 18798	B Ch. 7	Interpretations of NSTS/ISS Payload Safety Requirements
NSTS-21000-IDD-MDK	B Ch. 14	Shuttle/Payload Interface Definition Document for Middeck Accommodations
NT-CWI-001	A Ch. 2 07/31/01	Task Performance Sheet (TPS)
SAIC-TN-9550	12/01	Ionizing Radiation Dose Estimates for International Space Station Alpha Using the CADrays 3-D Mass Model
SN-C-0005	D Ch. 6	Space Shuttle Contamination Control Requirements
SP-T-0023	C	Specification, Environmental Acceptance Testing
SSP 30223	J	Problem Reporting and Corrective Action for the Space Station Program
SSP 30233	F	Space Station Requirements for Materials and Processes

Document Number	Revision	Document Title
SSP 30237	F Ch. 20	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP 30240	C Ch. 6	Space Station Grounding Requirements
SSP 30242	E Ch. 7	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility
SSP 30243	F	Space Station Requirements for Electromagnetic Compatibility
SSP 30245	E Ch. 16	Space Station Electrical Bonding Requirements
SSP 30257:004	E	Space Station Program Intravehicular Activity Restraints and Mobility Aids Standard ICD
SSP 30262:013	G	Smoke Detector Assembly Standard ICD
SSP 30312	H Ch. 1	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP 30423	H	Space Station Approved EEE Parts List
SSP 30512	C	Space Station Ionizing Radiation Design Environment
SSP 30695	A	Acceptance Data Package Requirements Specification
SSP 41002	K	International Standard Payload Rack to NASA/ESA/ NASDA Modules Interface Control Document
SSP 41017	F	Rack to Mini Pressurized Logistics Module Interface Control Document (ICD) Part 1
SSP 41017	H	Rack to Mini Pressurized Logistics Module Interface Control Document (ICD) Part 2
SSP 50005	C Ch. 8	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)
SSP 50008	C	International Space Station Interior Color Scheme
SSP 50467	Baseline	ISS Cargo Stowage Technical Manual: Pressurized Volume
SSP 52005	B	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 52051 Vol. 1	Basic	User Electric Power Specifications and Standards Volume 1: 120 Volt DC Loads
SSP 57000	E	Pressurized Payloads Interface Requirements Document

Document Number	Revision	Document Title
SSP 57001	C	Pressurized Payloads Hardware Interface Control Document Template
SSP 57020	A	Payload Accommodation Handbook
SSP 57245	Draft	MARES-HRF MARES Rack Hardware Interface Control Document
SSQ 21635	J	Connectors and Accessories, Electrical, Rectangular, Rack and Panel

2.2 ORDER OF PRECEDENCE

In the event of a conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 SYSTEM REQUIREMENTS

3.1 ITEM DEFINITION

The following items of the HRF MARES Rack will be designed and certified under this requirements document for use on International Space Station (ISS) as a part of the HRF program. The MARES hardware used with this hardware is certified under separate documentation that is maintained by the appropriate program(s).

Table 3.1-1 lists the equipment items covered by this document, including the stowage kits that will be used to transport the items and contain the items on-orbit.

TABLE 3.1-1. HRF MARES RACK ITEMS

Item Name	Notes
HRF MARES Rack Structure	Mounted to MPLM for launch, APM on-orbit
UIP-PIP Power Cable	Main J1 power, primary
PIP-MARES Power Cable	PIP to MARES cable
SUP/UOP Power Cable	SUP or UOP to PIP connection, secondary
UIP-PIP Data Cable	for RMS interface to J43
HRF MARES Rack Stowage Kit(s)	
PIP (Power Interface Panel)	Portable, mounted on seat tracks

3.1.1 System Description

The purpose of the HRF MARES Rack is to accommodate the stowage and deployment of the HRF MARES and to provide a power interface to a Standard Utility Panel (SUP), Utility Outlet Panel (UOP), or Utility Interface Panel (UIP). The HRF MARES Rack will launch in the Mini Pressurized Logistics Module (MPLM) on UF-3 and be installed in a rack space within the Attached Pressurized Module (APM). All HRF MARES Rack components except the rack structure will be stowed during launch.

The MARES and all its components, provided by the European Space Agency (ESA), will be launched on UF-3. During launch and landing, the MARES elements will either be mounted on the HRF MARES Rack structure or stowed in launch containers. During on-orbit operations, MARES will be deployed in the aisle. When not used on-orbit, MARES will be stowed.

Following transfer of this hardware to the APM, the MARES Main Box will be attached to the Vibration Isolation Frame (VIF). The VIF attaches to the HRF

MARES Rack structure via seat tracks. Further operations require attachment of the pantograph, chair and power cable prior to the first session. MARES power is obtained primarily through the rack UIP connector or secondarily via an SUP within the APM. Stowage will be within the rack space occupied by the HRF MARES Rack-MARES System. None of this hardware has a planned return flight.

The interfaces among the HRF MARES Rack components, MARES, and ISS are presented in Figure 3.1.1-1.

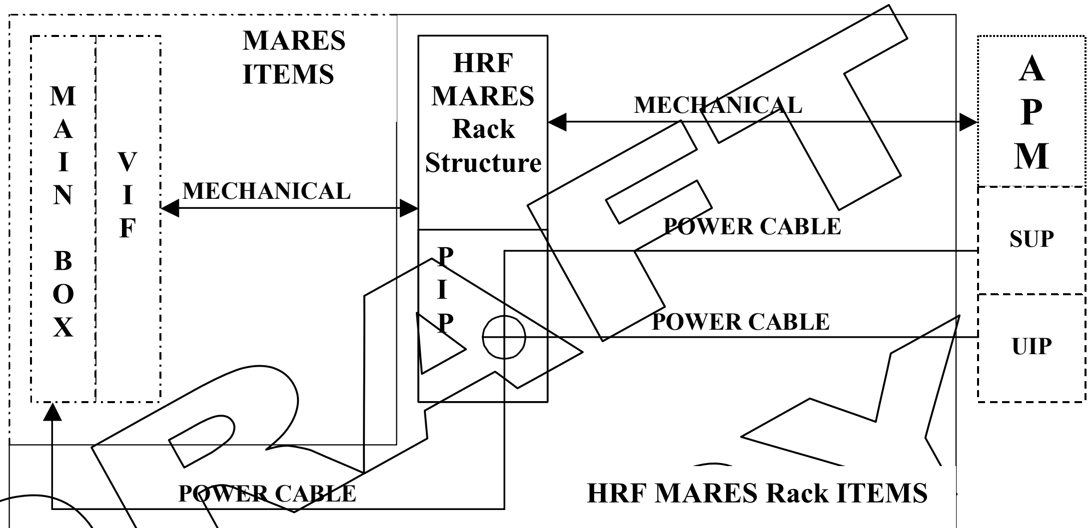


Figure 3.1.1-1. HRF MARES Rack Mechanical and Electrical Interfaces

3.1.1.1 Muscle Atrophy Research and Exercise System (MARES)

MARES will be used to carry out research on musculoskeletal, biomechanical, neuromuscular and neurological physiology, to study the effect of microgravity on the human being, and to evaluate the effect of the countermeasures to the space environment induced physiological effects. It can also be used to evaluate the performance of exercise tests protocols. The requirements for the MARES and its components are specified in LS-71053-1, HRD for the MARES of the HRF.

3.1.1.2 Vibration Isolation Frame (VIF)

The purpose of the VIF is to avoid perturbation of the microgravity environment of ISS while MARES is in use. At the same time, it keeps MARES in its correct position, and limits the range of displacement of the equipment. Requirements for the VIF are the responsibility of the MARES project team and are specified in the MARES HRD, LS-71053-1.

3.1.2 HRF MARES Rack Component Description

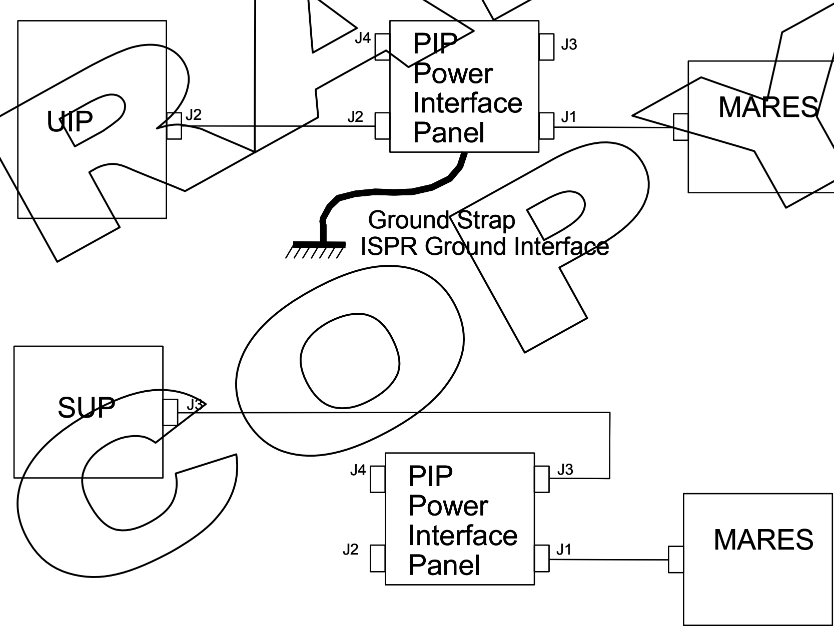
3.1.2.1 HRF MARES Rack Structure

The HRF MARES Rack structure is attached to the Columbus APM provided by ESA. The structure design will be based on an International Standard Payload Rack (ISPR). The HRF MARES Rack structure will allow for deployment and stowage of the MARES system within an empty rack space.

The HRF MARES Rack structure will also accommodate all MARES hardware manifested for UF-3 during launch.

3.1.2.2 Power Interface Panel (PIP)

The Power Interface Panel (PIP) is a portable power interface between the MARES and either the UIP, SUP, or UOP. The box may be relocated in support of the MARES. The interface concept for the UIP/SUP, PIP, and MARES is shown in Figure 3.1.2.2-1.



NOTE: Ground path for SUP interface is through the cable between SUP-J3 and PIP-J3.

Figure 3.1.2.2-1. Power Interface Panel Connections

3.1.2.3 UIP-PIP Power Cable

The UIP-PIP Power Cable is the electrical power cable that connects the APM's electrical power source on the UIP to the PIP. The nominal power source for the MARES when attached to the PIP will be the UIP.

3.1.2.4 Standard Utility Panel/Utility Outlet Panel Power Cable

The SUP/UOP Power Cable connects the aisle electrical power source on the SUP or UOP to the PIP. The SUP/UOP will be used as an alternative power source.

3.1.2.5 PIP-MARES Power Cable

The PIP-MARES Power Cable connects the PIP to the MARES Main Box.

3.1.2.6 UIP-PIP Data Cable

The UIP-PIP Data Cable connects the PIP to the UIP J43 connector. This cable is necessary to implement the Rack Maintenance Switch (RMS).

3.1.3 Interface Definition

3.1.3.1 Vibration Isolation Frame to HRF MARES Rack Interface

The VIF to HRF MARES Rack Interface is the mating plane of the connection that attaches the VIF to HRF MARES Rack. The VIF will attach to the HRF MARES Rack structure via seat tracks.

3.1.3.2 Utility Interface Panel Interface

Electrical power is supplied through the UIP connector on the Z-panel of the APM rack space. The UIP-PIP Power Cable is the interface that attaches the UIP to the PIP. The PIP-MARES Power Cable is used to connect the MARES to the PIP and provide the MARES Main Box its 120 Vdc electrical power.

An RMS is built into the PIP design. The UIP-PIP data cable connects the PIP to the UIP J43 connector to enable power to the HRF MARES Rack location in the APM.

3.1.3.3 Standard Utility Panel/Utility Outlet Panel Power Interface

Electrical power is supplied through the SUP connector in the APM. The SUP/UOP Power Cable is the interface between the SUP or UOP and the PIP. The PIP-MARES Power Cable is used to connect the MARES to the PIP and provide the MARES Main Box its 120 Vdc electrical power.

3.1.3.4 HRF MARES Rack to Attached Pressurized Module Structural Interface

The HRF MARES Rack structure attaches to the APM at existing rack attachment points.

3.1.3.5 HRF MARES Rack to MPLM Structural Interface

The HRF MARES Rack structure attaches to the MPLM at existing rack attachment points. The HRF MARES Rack structure will support MARES hardware during UF-3 launch.

3.1.3.6 HRF MARES Rack to MARES Main Box Structural Interface

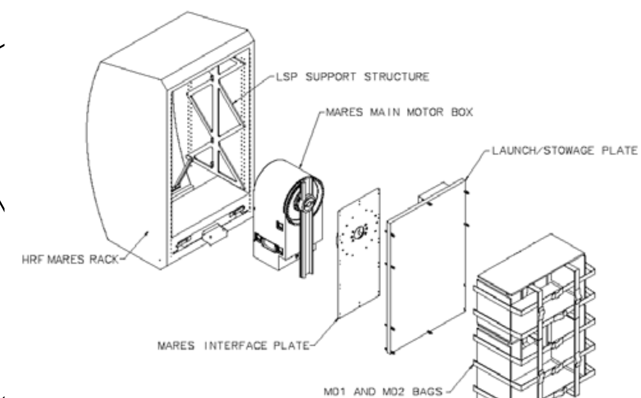
The HRF MARES Rack structure attaches to the MARES Main Box during UF-3 launch via a launch plate mounted within the structure. During on-orbit stowage, the Main Box attaches to the structure by utilizing the same attachment points as the Main Box to VIF interface. This interface will allow easy removal of the Main Box for on-orbit use.

3.1.4 Operations

3.1.4.1 Launch/Landing Operation

The HRF MARES Rack structure will be launched in the MPLM on UF-3. The HRF MARES Rack structure will be installed into the APM on-orbit. All components will be stowed during launch and are neither powered nor operated.

All MARES hardware that is utilized for on-orbit checkout will be flown during UF-3. The HRF MARES Rack will accommodate this hardware in some fashion during launch in the MPLM, whether mounted to the HRF MARES Rack structure or stored in containers. The launch mounting concept is shown in Figure 3.1.4.1-1.

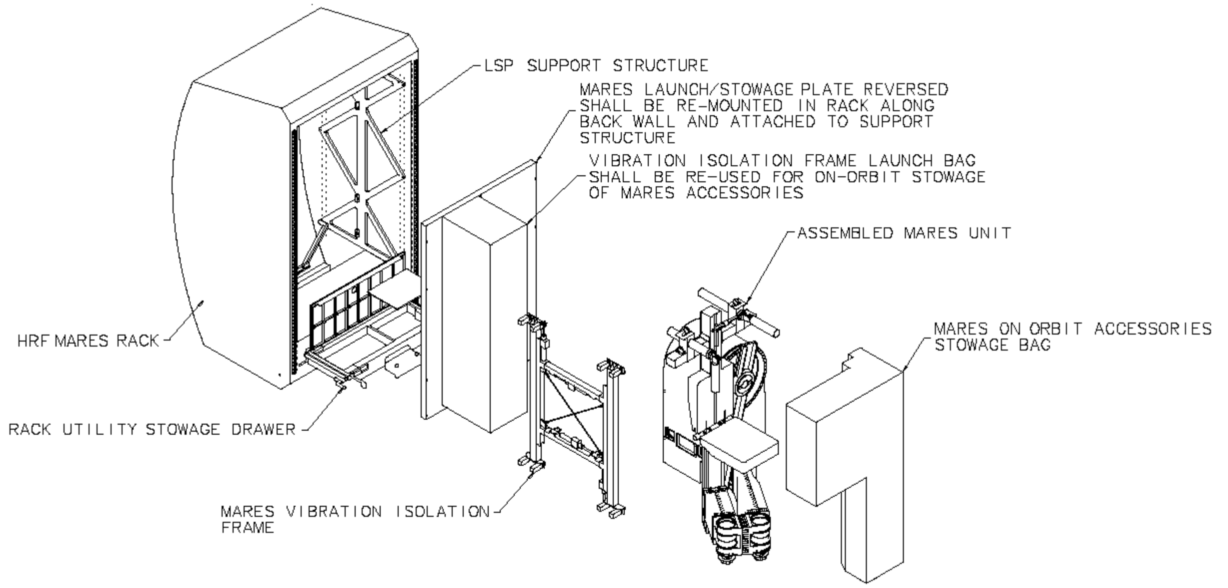


NOTE: This figure is for descriptive purposes only. It is not the complete hardware design nor to be used to determine applicability of requirements.

Figure 3.1.4.1-1. HRF MARES Rack Launch Concept - Exploded

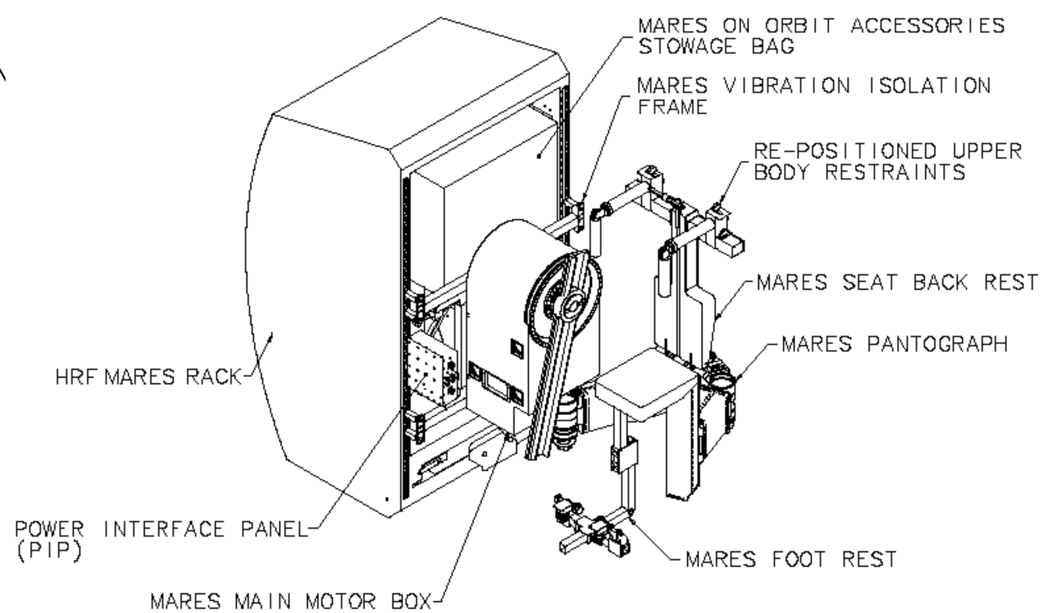
3.1.4.2 On-Orbit Operation

The HRF MARES Rack and MARES hardware will be transferred to the APM following launch. The VIF will be attached to the HRF MARES Rack for on-orbit stowage and use via standard seat tracks. The MARES Main Box, Pantograph, and Chair are attached to the VIF for on-orbit use, and detached for stowage. Hardware accessories will be placed in the free space around the Main Box, Pantograph, Chair and VIF for on-orbit stowage. All MARES accessories will be deployed only when needed for operations. The on-orbit stowage and deployment concepts are shown in Figures 3.1.4.2-1 and 3.1.4.2-2 respectively.



NOTE: This figure is for descriptive purposes only. It is not the complete hardware design nor to be used to determine applicability of requirements.

Figure 3.1.4.2-1. HRF MARES Rack On-orbit Stowage Concept - Exploded



NOTE: This figure is for descriptive purposes only. It is not the complete hardware design nor to be used to determine applicability of requirements.

Figure 3.1.4.2-2. HRF MARES Rack On-orbit Deployment Concept

3.2 CHARACTERISTICS

3.2.1 Functional Performance Characteristics

a. HRF MARES Rack shall provide stowage capability for all MARES hardware.

3.2.2 Physical Characteristics

3.2.2.1 Mass and Center of Gravity Properties

Integrated racks shall be limited to 804.2 kg (1773 lbs) for launch and landing in the MPLM and for ground and on-orbit operations. [SSP 57000, paragraph 3.1.1.4A]

Center of gravity data for the HRF MARES Rack shall be provided for integration purposes.

3.2.2.2 Envelope

3.2.2.2.1 Stowed Envelope

Stowage interface information is provided in SSP 50467, ISS Stowage Accommodations Handbook: Pressurized Volume.

3.2.2.2.2 Deployed Envelope

3.2.2.2.2.1 On-Orbit Payload Protrusions

Definitions for on-orbit permanent protrusions, on-orbit semi-permanent protrusions, on-orbit temporary protrusions, on-orbit momentary protrusions, and protrusions for on-orbit keep alive payloads can be found in Section 6.1, Definitions. The requirements in Section 3.2.2.2.2.1 apply to installation and operation activities, but not to maintenance activities.

NOTE: The on-orbit protrusion requirements in this section are applicable to when the payload is on-orbit and do not apply to other phases of the transportation of the payload [e.g., launch, landing, Mini Pressurized Logistics Module (MPLM) installation]. [SSP 57000, Section 3.1.1.7]

A. On-orbit protrusions, excluding momentary protrusions, shall not extend laterally across the edges of the rack or pass between racks. [SSP 57000, Section 3.1.1.7.A]

B. The HRF MARES Rack, excluding momentary protrusions, shall not prevent attachment of Rack Mounting Adapter (RMA) on any seat track attach holes. [SSP 57000, Section 3.1.1.7.B]

Constraints which may be associated with payload protrusions include:

- removal of the protrusion during rack installation, translation, and crew translation
- removal of the protrusion if RMA is installed on the rack
- removal of the protrusion to prevent interference with microgravity operations
- removal or powering off of the rack if the protrusion blocks Portable Fire Extinguisher (PFE) access or the fire indicator
- may limit the rack location (e.g., Protrusion located in the floor and the ceiling are limited to a total of no more than 12 inches.)
- may limit operation of the payload

As is indicated by the constraints above, protrusions have a negative impact on crew operations and are to be minimized. [SSP 57000, paragraph 3.1.1.7]

3.2.2.2.2.1.1 On-Orbit Permanent Protrusions

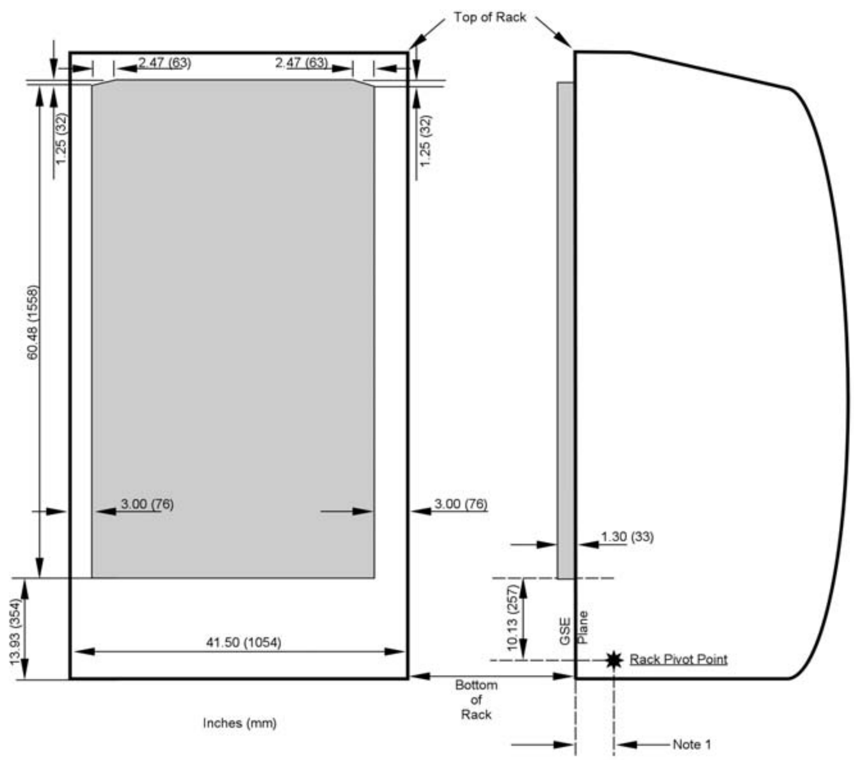
Not applicable (N/A). HRF MARES Rack has no permanent protrusions.

3.2.2.2.2.1.2 On-Orbit Semi-Permanent Protrusions

A. Not applicable. Rack Insertion Device (RID) plate requirement which is no longer valid.

B. Other on-orbit semi-permanent protrusions shall be limited to no more than 500 square inches within the envelope shown in Figure 3.2.2.2.2.1.2-1. [SSP 57000, paragraph 3.1.1.7.2.B]

C. All on-orbit semi-permanent protrusions shall be designed to be removable by the crew with hand operations and/or standard Intravehicular Activity (IVA) tools. [SSP 57000, paragraph 3.1.1.7.2.C]



Note:
1. The dimension for a Boeing ISPR is 3.50 (89). The dimension for a NASDA ISPR is 2.47 (63).
2. Protrusions are limited to 1.3 (33 mm) inches for ground processing and launch/landing as described in paragraph 3.1.1.1.A

NOTE: All sections mentioned in figure refer to the applicable section of SSP 57000.

Figure 3.2.2.2.2.1.2-1. On-Orbit Semi-Permanent Protrusions Envelope

3.2.2.2.2.1.3 On-Orbit Temporary Protrusions

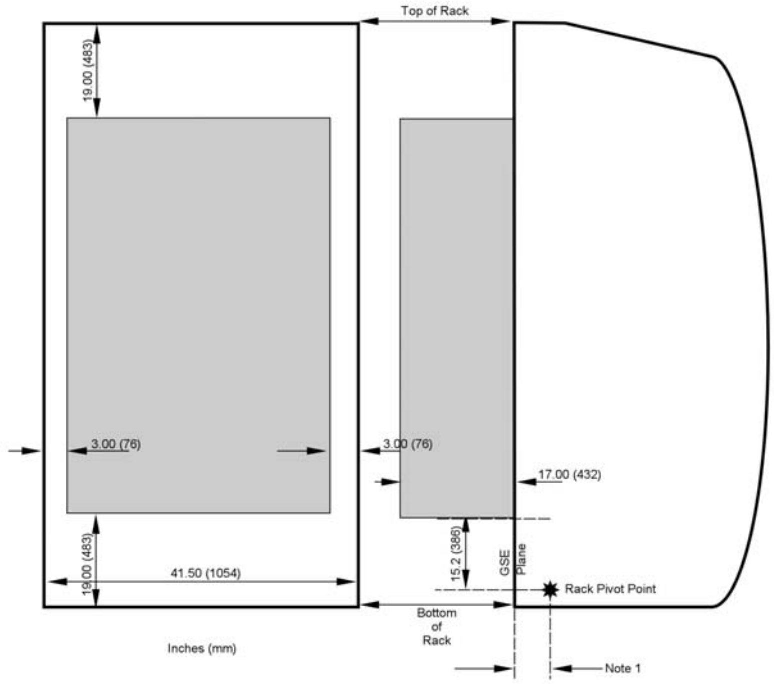
A. On-orbit temporary protrusions shall remain within the envelope shown in Figure 3.2.2.2.2.1.3-1. [SSP 57000, paragraph 3.1.1.7.3.A]

B. The combination of all on-orbit temporary protrusions for the integrated HRF MARES Rack/MARES shall be designed such that they can be eliminated or returned to their stowed configuration by the crew with hand operations and/or standard IVA tools within 10 minutes. [SSP 57000, paragraph 3.1.1.7.3.B]

NOTE: HRF MARES Rack must provide stowage for on-orbit temporary protrusions within its stowage allocation. [SSP 57000, paragraph 3.1.1.7.3]

NOTE: On-orbit temporary protrusions for payloads located in the floor or ceiling are limited to 6 inches each or a total of 12 inches for both floor and ceiling. [SSP 57000, paragraph 3.1.1.7.3]

Note: On-orbit temporary protrusions for payloads located in the floor or ceiling are limited to 6 inches each or a total of 12 inches for both floor and ceiling.



Note:
1. The dimension for a Boeing ISPR is 3.50 (89). The dimension for a NASDA ISPR is 2.47 (63).
2. Protrusions are limited to 1.3 (33 mm) inches for ground processing and launch/landing as described in paragraph 3.1.1.1.A
3. The A1 and F1 positions in the JEM can not accommodate temporary protrusions due to the interference with the Intermodule Ventilation (IMV) function.

NOTE: All sections mentioned in figure refer to the applicable section of SSP 57000.

Figure 3.2.2.2.2.1.3-1. On-Orbit Temporary Protrusions Envelope

3.2.2.2.2.1.4 On-Orbit Momentary Protrusions

Not applicable to HRF MARES Rack. HRF MARES Rack has no momentary protrusions.

3.2.2.2.2.2 Deployed Envelope Dimensions

The HRF MARES Rack deployed envelope dimensions are dependent on the MARES hardware. Deployed envelope dimensions will be measured and verified at an integrated hardware level and is outside the scope of this document.

3.2.3 Reliability, Quality and Non-Conformance Reporting

A. Reliability is ensured by compliance with the applicable qualification and acceptance tests documented in Section 3.4 and by compliance with the useful life requirement documented in Section 3.2.3.2. HRF hardware maintainability is ensured by compliance with the applicable ISS maintainability requirements derived from SSP 57000 and documented in Section 3.0.

B. Quality Assurance for the HRF Program shall be implemented in accordance with JPD 5335.1, “JSC Quality Manual”. [LS-71000, Section 7.3.1]

C. Non-Conformance Reporting

1. For flight hardware produced under a contract or subcontract at a site other than Johnson Space Center (JSC), non-conformance reporting requirements shall be specified in the Statement of Work (SOW) Data Requirements List, and Data Requirements Documents (DRDs) shall be used to identify the submittal and data requirements. [LS-71000, Section 7.3.2.1]

2. For flight hardware developed at JSC, non-conformance reporting shall be in accordance with JPD 5335.1 and the applicable technical division plan. [LS-71000, Section 7.3.2.2]

3. Non-conformances, which meet the Level 1 Problem Reporting and Corrective Action criteria for payloads as defined in SSP 30223, shall be reported in accordance with SSP 30223. [LS-71000, Section 7.3.2.3]

4. Software non-conformance reporting is not applicable to HRF MARES Rack.

3.2.3.1 Failure Propagation

The design shall preclude propagation of failures from the payload to the environment outside the payload. [NSTS 1700.7B, Section 206]

3.2.3.2 Useful Life

HRF MARES Rack hardware shall be designed for a 10-year utilization. [LS-71000, Section 7.2.1]

3.2.3.2.1 Operational Life (Cycles)

Operational life applies to any hardware that deteriorates with the accumulation of operating time and/or cycles and thus requires periodic replacement or refurbishment to maintain acceptable operating characteristics. Operational life includes the usage during flight, ground testing and pre-launch operations. All components of the HRF MARES Rack shall have an operational life limit of 10 years.

3.2.3.2.2 Shelf Life

Shelf life is defined as that period of time during which the components of a system can be stored under controlled conditions and put into service without replacement of parts (beyond servicing and installation of consumables). Shelf life items shall be identified and tracked on a list that is maintained as a part of the hardware acceptance data pack.

3.2.3.2.3 Limited Life

Limited life is defined as the life of a component, subassembly, or assembly that expires prior to the stated operational life in Section 3.2.3.2.1. Limited life items or materials, such as soft goods, shall be identified and the number of operation cycles shall be determined. Limited life items shall be tracked on a limited life list that is maintained as a part of the hardware acceptance data pack.

3.2.4 Maintainability

A. Not applicable. HRF MARES Rack contains no payload unique tools.

B. All Orbital Replacement Unit (ORU) connectors, whether operated by hand or tool, shall be designed and placed so they can be mated/demated using either hand. [LS-71000, Section 6.4.4.3.1]

C. It shall be possible to mate/demate individual connectors without having to remove or mate/demate connectors on other ORUs or payloads during maintenance operations. [LS-71000, Section 6.4.4.3.2B]

D. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors. [LS-71000, Section 6.4.4.3.2C]

E. Access to inspect or replace a hardware item (e.g., an ORU) which is planned to be accessed on a daily or weekly basis shall not require removal of another hardware item or more than one access cover. [LS-71000, Section 6.4.4.2.6]

F. Not applicable. HRF MARES Rack has no containers of liquids or particular matter.

G. Not applicable. HRF MARES Rack has no capture elements.

3.2.4.1 Logistics and Maintenance

3.2.4.1.1 Payload In-Flight Maintenance

Payloads shall be designed to be maintainable using Space Station provided onboard tools. A list of available tools on-orbit is defined in the Payload Accommodations Handbook. [SSP 57000, paragraph 3.12.10]

3.2.4.1.2 Maintenance

There are no scheduled or unscheduled maintenance requirements for HRF MARES Rack.

3.2.5 Environmental Conditions

3.2.5.1 On-Orbit Environmental Conditions

3.2.5.1.1 On-Orbit Internal Environments

3.2.5.1.1.1 Pressure

The HRF MARES Rack shall be safe when exposed to pressures of 0 to 104.8 kPa (0 to 15.2 psia). [SSP 57000, paragraph 3.9.1.1]

3.2.5.1.1.2 Temperature

The HRF MARES Rack shall be safe when exposed to temperatures of 10 to 46 °C (50 to 115 °F). [SSP 57000, paragraph 3.9.1.2]

3.2.5.1.1.3 Humidity

Not applicable to the HRF MARES Rack.

3.2.5.1.2 Integrated Rack Use of Cabin Atmosphere

3.2.5.1.2.1 Active Air Exchange

Not applicable. HRF MARES Rack has no active air exchange.

3.2.5.1.2.2 Oxygen Consumption

Not applicable. HRF MARES Rack has no equipment or process that consumes oxygen.

3.2.5.1.2.3 Chemical Releases

Chemical releases to the cabin air shall be in accordance with paragraphs 209.1a and 209.1b in NSTS 1700.7B, ISS Addendum. [SSP 57000, paragraph 3.9.2.3]

3.2.5.1.2.4 Cabin Air Heat Leak

The sensible heat leak to the cabin air from the HRF MARES Rack either alone or together with the other ISPRs simultaneously active will not exceed the limits specified in paragraph 3.5.1.8 of the Pressurized Payload Hardware Interface Control Document, SSP 57001. These limits represent the total cabin air heat load capability when the cabin temperature is at 18 °C (65 °F). The numbers in Table 3.5.1.8-1 of SSP 57001 are the total cabin heat load allocation for all the ISPRs on a module basis. [SSP 57000, paragraph 3.5.1.12]

3.2.5.1.3 Ionizing Radiation Requirements

3.2.5.1.3.1 Human Research Facility MARES Rack Contained or Generated Ionizing Radiation

Integrated racks containing or using radioactive materials or that generate ionizing radiation shall comply with NSTS 1700.7, ISS Addendum, paragraph 212.1. [SSP 57000, paragraph 3.9.3.1]

3.2.5.1.3.2 Ionizing Radiation Dose

HRF MARES Rack should expect a total dose (including trapped protons and electrons) of 30 Rads(Si) per year of ionizing radiation. A review of the dose estimates in the ISS (SAIC-TN-9550) may show ionizing radiation exposure to be different than 30 Rads(Si) per year, if the intended location of the rack in the ISS is known. [SSP 57000, paragraph 3.9.3.2]

3.2.5.1.3.3 Single Event Effect Ionizing Radiation

Equipment and subsystems shall be designed not to produce an unsafe condition or one that could cause damage to equipment external to the HRF MARES Rack as a result of exposure to Single Event Effect (SEE) ionizing radiation assuming exposure levels specified in SSP 30512, paragraph 3.2.1, with a shielding thickness of 25.4 mm (1000 mils). [SSP 57000, paragraph 3.9.3.3]

3.2.5.1.4 Additional Environmental Conditions

The environmental information provided in Table 3.2.5.1.4-1, Environmental Conditions on ISS, and Figure 3.2.5.1.4-1, Operating Limits of the ISS Atmospheric Total Pressure, Nitrogen and Oxygen Partial Pressures, is for design and analysis purposes. [SSP 57000, paragraph 3.9.3.4]

3.2.5.1.5 Pressure Rate of Change

A. HRF MARES Rack shall maintain positive margins of safety for the on-orbit depress/repress rates identified in SSP 41002 paragraph 3.1.7.2.1. [SSP 57000, paragraph 3.1.1.4.B]

B. HRF MARES Rack shall maintain positive margins of safety for MPLM depress rates of 890 Pa/second (7.75 psi/minute) and repress rates of 800 Pa/second (6.96 psi/minute). [SSP 57000, paragraph 3.1.1.2.B]

C. Not applicable. HRF MARES Rack does not have a PFE access port.

D. Not applicable. HRF MARES Rack has no pressure relief devices.

3.2.5.2 Acoustic Emission Limits

Not applicable. HRF MARES Rack contains no acoustic sources.

TABLE 3.2.5.1.4-1. ENVIRONMENTAL CONDITIONS ON ISS

Environmental Conditions	Value	
Atmospheric Conditions on ISS		
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)	
Normal operating pressure	See Figure 3.2.5.1.4-1	
Oxygen partial pressure	See Figure 3.2.5.1.4-1	
Nitrogen partial pressure	See Figure 3.2.5.1.4-1	
Dewpoint	4.4 to 15.6 °C (40 to 60 °F) ref. Figure 3.9.1.3-1 of SSP 57000	
Percent relative humidity	25 to 75% ref. Figure 3.9.1.3-1 of SSP 57000	
Carbon dioxide (CO2) partial pressure during normal operations with 6 crewmembers plus animals	24-hr average exposure 5.3 mmHg Peak exposure 7.6 mmHg	
CO2 partial pressure during crew changeout with 11 crewmembers plus animals	24-hr average exposure 7.6 mmHg Peak exposure 10 mmHg	
Cabin air temperature in USL, JEM, APM and CAM	17 to 28 °C (63 to 82 °F)	
Cabin air temperature in Node 1	17 to 31 °C (63 to 87 °F)	
Air velocity (nominal)	0.051 to 0.203 m/s (10 to 40 ft/min)	
Airborne microbes	Less than 1000 CFU/m3	
Atmosphere particulate level	Average less than 100,000 particles/ft3 for particles less than 0.5 microns in size	
MPLM Air Temperatures	Passive Flights	Active Flights
Pre-Launch	15 to 24 °C (59 to 75.2 °F)	14 to 30 °C (57.2 to 86 °F)
Launch/Ascent	14 to 24 °C (57.2 to 75.2 °F)	20 to 30 °C (68 to 86 °F)
On-Orbit (Cargo Bay + Deployment)	24 to 44 °C (75.2 to 111.2 °F)	16 to 46 °C (60.8 to 114.8 °F)
On-Orbit (On-Station)	23 to 45 °C (73.4 to 113 °F)	16 to 43 °C (60.8 to 109.4 °F)
On-Orbit (Retrieval + Cargo Bay)	17 to 44 °C (62.6 to 111.2 °F)	11 to 45 °C (51.8 to 113 °F)
Descent/Landing	13 to 43 °C (55.4 to 109.4 °F)	10 to 42 °C (50 to 107.6 °F)
Post-Landing	13 to 43 °C (55.4 to 109.4 °F)	10 to 42 °C (50 to 107.6 °F)
Ferry Flight	15.5 to 30 °C (59.9 to 86 °F)	15.5 to 30 °C (59.9 to 86 °F)
MPLM Maximum Dewpoint Temperatures		
Pre-Launch	13.8 °C (56.8 °F)	12.5 °C (54.5 °F)
Launch/Ascent	13.8 °C (56.8 °F)	12.5 °C (54.5 °F)
On-Orbit (Cargo Bay +Deployment)	13.8 °C (56.8 °F)	12.5 °C (54.5 °F)
On-Orbit (On Station)	15.5 °C (60 °F)	15.5 °C (60 °F)
On-Orbit (Retrieval +Cargo Bay)	10 °C (50 °F)	10 °C (50 °F)
Descent/Landing	10 °C (50 °F)	10 °C (50 °F)
Post Landing	10 °C (50 °F)	10 °C (50 °F)
Ferry Flight	15.5 °C (60 °F)	15.5 °C (60 °F)
Thermal Conditions		
USL module wall temperature	13 °C to 43 °C (55 °F to 109 °F)	
JEM module wall temperature	13 °C to 45 °C (55 °F to 113 °F) (TBR #7)	
APM module wall temperature	13 °C to 43 °C (55 °F to 109 °F) (TBR #8)	
CAM module wall temperature	13 °C to 43 °C (55 °F to 109 °F) (TBR #9)	
Other integrated payload racks	Front surface less than 37 °C (98.6 °F)	
***Microgravity**		
Quasi-Steady State Environment	See SSP 57000 Figures 3.9.4-2, 3.9.4-3 and Table 3.9.4-2	
Vibro-accoustic Environment	See SSP 57000 Figure 3.9.4-4	
General Illumination	108 Lux (10 fc) measured 30 inches from the floor in the center of the aisle	

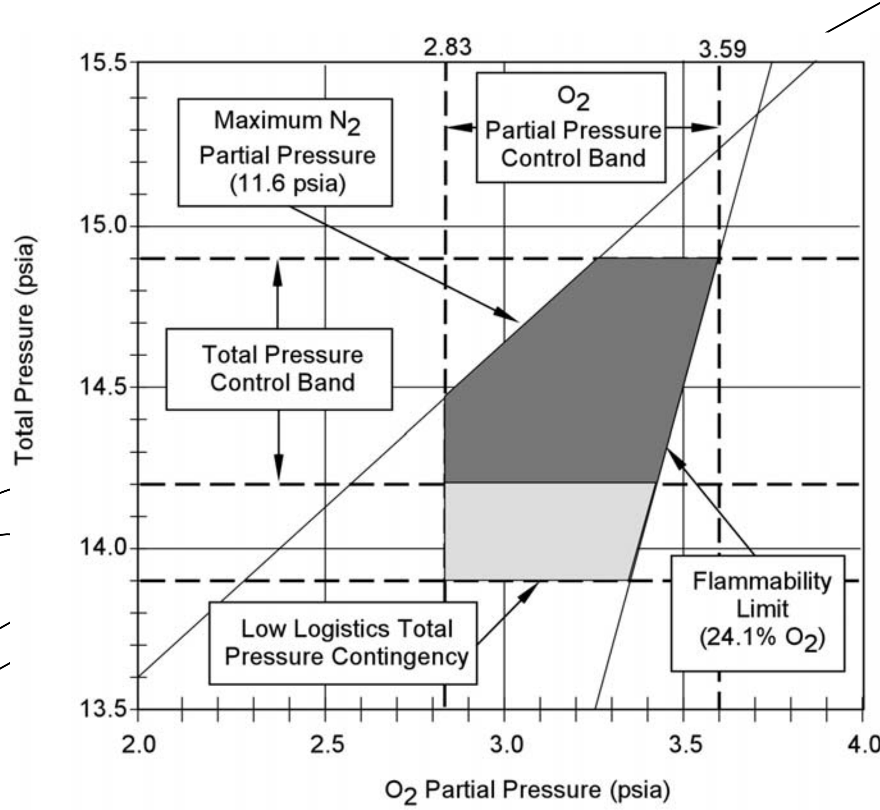


Figure 3.2.5.1.4-1. Operating Limits of the ISS Atmospheric Total Pressure, Nitrogen and Oxygen Partial Pressures

3.2.5.3 Lighting Design

The general illumination of the space station in the aisle will be a minimum of 108 lux (10 foot candles) of white light. This illumination will be sufficient for ordinary payload operations performed in the aisle (e.g., examining dials or panels, reading procedures, transcription, tabulation, etc.).

Payloads will meet the following requirements:

A. Payload work surface specularity shall not exceed 20 percent. Paints listed in Table 3.2.5.3-1 meet this requirement. [LS-71000, Section 6.4.3.4A]

B. Lighting levels for tasks to be performed at payload worksites shall be provided, as defined in Table 3.2.5.3-2. [LS-71000, Section 6.4.3.4B]

C. Not applicable to HRF MARES Rack.

D. Not applicable to HRF MARES Rack.

E. Not applicable to HRF MARES Rack.

TABLE 3.2.5.3-1. SURFACE INTERIOR COLORS AND PAINTS

Hardware Description	Color	Finish	Paint Specification Per FED-STD-595
Equipment Rack Utility Panel Recess	White	Semigloss	27925
Equipment Rack Utility Panel Text Characters	Black	Lusterless	37038
ISPR Utility Panel Recess	White	Semigloss	27925
ISPR Utility Panel Recess Text Characters	Black	Lusterless	37038
Functional Unit Utility Panel Recess (as applicable)	White	Semigloss	27925
Functional Unit Utility Panel Recess Text Characters	Black	Lusterless	37038
Rack Front Aisle Extensions	Off-White	Semigloss	27722
Overhead Rack Face Plates	Off-White	Semigloss	27722
Port Rack Face Plates	Off-White	Semigloss	27722
Starboard Rack Face Plates	Off-White	Semigloss	27722
Deck Rack Face Plates	Off-White	Semigloss	27722
Overhead Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Port Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Starboard Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Deck Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Stowage Trays	Off-White	Semigloss	27722
Stowage Tray Handle Straps (any location)	Blue material	Semigloss	25102 or equiv.
Common Seat Track Interface	Clear (Anodized)	Semigloss	none
Glovebox (Aluminum or Plastic)	Medium Gray	Gloss	16329 or 16373
Glovebox (Aluminum)	White	Gloss	17925
Glovebox (Aluminum or Plastic)	Off-White	Gloss	17722
Glovebox (Aluminum)	Tan	Gloss	10475
EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Program Rack Utility Panels	Off-White	Gloss	17875

TABLE 3.2.5.3-2. PAYLOAD REQUIRED ILLUMINATION LEVELS

Type of Task	Required Lux (Foot-Candles)*
Medium payload operations (not performed in the aisle) (e.g., payload change-out and maintenance)	325 (30)
Fine payload operations (e.g., instrument repair)	1075 (100)
Medium glovebox operations (e.g., general operations, experiment set-up)	975 (90)
Fine glovebox operations (e.g., detailed operations, protein crystal growth, surgery/dissection, spot illumination)	1450 (135)

*As measured at the task site

3.2.6 Transportability

3.2.6.1 Launch and Landing

Not applicable. HRF MARES Rack hardware is not transported to and from orbit in a stowage locker.

3.2.7 Operational Interface Requirements

3.2.7.1 Mechanical Interface Requirements

3.2.7.1.1 Ground Support Equipment Interfaces

A. HRF MARES Rack shall interface to the Kennedy Space Center (KSC) Ground Support Equipment (GSE) Rack Insertion Device in accordance with SSP 41017 Part 1, paragraph 3.2.1.1.2 Static Envelope, 3.2.1.4.3 Interface Loads, and SSP 41017 Part 2, paragraph 3.3.2 Upper Attachment Interfaces and 3.3.3 Ground Handling Attachment Interfaces. [SSP 57000, paragraph 3.1.1.1.A]

B. HRF MARES Rack shall interface to Rack Shipping Containers in accordance with the Teledyne Brown Engineering (TBE) as-built drawing 220G07500. [SSP 57000, paragraph 3.1.1.1.B]

C. HRF MARES Rack shall interface to Rack Handling Adapters (RHAs) in accordance with the following TBE as-built drawings: 220G07455 Upper Structure Assembly, 220G07470 MSFC Base Assembly, and 220G07475 SSPF Base Assembly. [SSP 57000, paragraph 3.1.1.1.C]

D. HRF MARES Rack shall be limited to ground transportation accelerations of 80% of flight accelerations defined by SSP 41017 Part 1, paragraph 3.2.1.4.2. [SSP 57000, paragraph 3.1.1.1.D]

3.2.7.1.2 Module Interfaces

3.2.7.1.2.1 MPLM Interfaces

A. HRF MARES Rack shall interface to the MPLM structural attach points in accordance with SSP 41017 Part 2, paragraph 3.1.1. [SSP 57000, paragraph 3.1.1.2.A]

B. HRF MARES Rack shall be limited to producing interface attach point loads less than or equal to those identified by SSP 41017 Part 1, paragraph 3.2.1.4.3, based upon an acceleration environment as defined in SSP 41017 Part 1, paragraph 3.2.1.4.2. [SSP 57000, paragraph 3.1.1.2.E]

3.2.7.1.3 HRF MARES Rack Structure Requirements

A. HRF MARES Rack shall comply with the keepout zone for rack pivot mechanism as defined in SSP 41017 Part 1, paragraph 3.2.1.1.2. [SSP 57000, paragraph 3.1.1.4.E]

B. HRF MARES Rack with and/or without MARES installed shall be capable of rotating a minimum of 80 degrees about the pivot point for on-orbit installation, removal, and maintenance functions. [SSP 57000, paragraph 3.1.1.4.I]

C. An HRF MARES Rack requiring rotation shall use the rack and crew restraints identified in SSP 30257:004 (for example, the 14-inch fixed length tether and the 71-inch adjustable length tether) to secure the rack in these rotated positions for payload operations and maintenance. [SSP 57000, paragraph 3.1.1.4.L]

3.2.7.1.4 Connector and Umbilical Physical Mate

3.2.7.1.4.1 Connector Physical Mate

HRF MARES Rack shall physically mate with the UIP, UOP, SUP, and Fluid Services connectors intended to be used by the payload as listed in Table 3.2.7.1.4.1-1. [SSP 57000, paragraph 3.1.1.6.1]

3.2.7.1.4.2 Umbilical Physical Mate

HRF MARES Rack shall provide a PIP and umbilicals that allow connection of rack utilities from the rack to the standoff UIP defined in SSP 41002, Figure 3.2.2-1 and the appropriate UIP connector layout defined in SSP 41002 Figures 3.3-1 through 3.3-5. [Derived from SSP 57000, paragraph 3.1.1.6.2]

TABLE 3.2.7.1.4.1-1. MODULE CONNECTORS

	Module Connector	Module Part Number	Resource
		UIP	
A	J1	NATC07T25LN3SN	Main Power
B	J2	NATC07T25LN3SA	Essential/Auxiliary Power
C	J3	NATC07T15N35SN	1553 Bus A
D	J4	NATC07T15N35SA	1553 Bus B
E	J7	NATC07T13N4SN	High Rate Data Link (HRDL)
F	J16	NATC07T15N97SB	Optical Video
G	J43	NATC07T13N35SA	FDS/Power Maintenance
H	J45	NATC07T11N35SC	Emergency Warning and Caution System (EWACS)
I	J46	NATC07T11N35SA	LAN-1
J	J47	NATC07T11N35SB	LAN-2
K	J77	NATC07T13N35SB	Electrical Video
L	Thermal Control System (TCS) Mod	683-16348, male, Category 6, Keying B	TCS Mod Supply
M	TCS Mod	683-16348, male, Category 6, Keying C	TCS Mod Return
N	TCS Low	683-16348, male, Category 6, Keying B	TCS Low Supply
O	TCS Low	683-16348, male, Category 6, Keying C	TCS Low Return
P	Gaseous Nitrogen (GN2)	683-16348-352	GN2
Q	Vacuum Exhaust	683-16348, male, Category 3, Keying B	Vacuum Exhaust
R	Vacuum Resource	683-16348, male, Category 3, Keying A	Vacuum Resource
S	Argon (Ar)	683-16348, male, Category 8, Keying C	AR
T	Helium (He)	683-16348, male, Category 8, Keying E	HE
U	CO2	683-16348, male, Category 8, Keying D	CO2
		FLUID SERVICES	
V	Potable Water	683-16348, male, Category 7, Keying D	Potable Water
W	Fluid System Servicer (FSS)	per Dwg 683-16348, male, 0.50 QD, Universal (no-keying)	FSS
		UOP	
X	J3	NATC00T15N97SN	Power/1553 Bus
Y	J4	NATC00T15N97SN	Power/1553 Bus
Z	J4	NATC00T15N97SA	Power/Ethernet
NOTES: 1. Integrated rack connector part numbers are listed in the appropriate sections of SSP 57001. 2. UOP connector architecture is specified in SSP 57001, paragraph 3.2.7.1.			
		SUP	
AA	J1	NATC00T15N97SN	Power/Data
AB	J2	NATC00T15N97SN	Power/Data
AC	J3	NATC00T15N97SN	Power
AD	J4 (SUP - 1 & 4 only)	NATC00T15N35SN	APM Payload 1553 Bus
AE	J5	NATC00T11N35SN	APM Institute of Electrical and Electronic Engineers (IEEE) 802.3 Nominal Local Area Network (LAN)
AF	J6 (SUP - 1 & 4 only)	NATC00T15N97SN	Video/High Rate Data
AG	J7 (SUP - 1 & 4 only)	NATC00T13N35SA	Smoke Sensor/EWACS
AH	J8	Reserved	Reserved
AI	J9	NATC00T11N35SN	APM IEEE 802.3 Redundant LAN

3.2.7.2 Electrical Power Interface Requirements

Electrical power characteristics are specified in this section for two interfaces, Interfaces B and C, as depicted in Figure 3.2.1-1, Electrical Power System Interface Locations, of SSP 57000. Integrated racks, payload associated hardware and payload hardware connected to UOPs in the U.S. Lab (USL), Japanese Experiment Module (JEM), and Centrifuge Accommodation Module (CAM) or the SUPs in the APM are required to be compatible with the prescribed characteristics of the Electrical Power System (EPS). For purposes of this specification, compatibility is defined as operating without producing an unsafe condition or one that could result in damage to ISS equipment or payload hardware. [SSP 57000, paragraph 3.2.1]

3.2.7.2.1 Steady-State Voltage Characteristics

3.2.7.2.1.1 Interface B

The HRF MARES Rack at Interface B shall operate and be compatible with the steady-state voltage limits of 116 to 126 Vdc. [SSP 57000, paragraph 3.2.1.1.1]

3.2.7.2.1.2 Interface C

The HRF MARES Rack at Interface C shall operate and be compatible with the steady-state voltage limits of 113 to 126 Vdc. [SSP 57000, paragraph 3.2.1.1.2]

3.2.7.2.2 Ripple Voltage Characteristics

3.2.7.2.2.1 Ripple Voltage and Noise

The HRF MARES Rack shall operate and be compatible with the EPS time domain ripple voltage and noise level of 2.5 Vrms maximum within the frequency range of 30 Hz to 10 kHz. [SSP 57000, paragraph 3.2.1.2.1]

3.2.7.2.2.2 Ripple Voltage Spectrum

The HRF MARES Rack shall operate and be compatible with the EPS ripple voltage spectrum as shown in Figure 3.2.1.2.2-1 of SSP 57000. [SSP 57000, paragraph 3.2.1.2.2]

NOTE: This limit is 6 dB below the Electromagnetic Compatibility (EMC) CS-01, 02 requirement in SSP 30237 up to 30 MHz.

3.2.7.2.3 Transient Voltages

3.2.7.2.3.1 Interface B

The Electrical Power Consuming Equipment (EPCE) at Interface B shall operate and be compatible with the limits of magnitude and duration for the voltage transients at Interface B as shown in Figure 3.2.1.3.1-1 of SSP 57000. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple and/or random noise components that may be present. [SSP 57000, paragraph 3.2.1.3.1]

<u>NOTE</u>: APM EPS transients less than 100 microseconds (μs) are defined in COL-RQ-ESA-014, paragraphs 4.1.5.3 and 4.1.7.2. (in compliance with CS06 requiring a 10 ms pulse injection). Payloads meeting CS06 requirements in SSP 30237 are in compliance with the APM requirements.

3.2.7.2.3.2 Interface C

The EPCE at Interface C shall operate and be compatible with the limits of magnitude and duration for the voltage transients at Interface C as shown in Figure 3.2.1.3.2-1 of SSP 57000. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple or noise components that may be present. [SSP 57000, paragraph 3.2.1.3.2]

<u>NOTE</u>: APM EPS transients less than 100 microseconds are defined in COL-RQ-ESA-014, paragraphs 4.1.5.3 and 4.1.7.2. (in compliance with CS06 requiring a 10 ms pulse injection). Payloads meeting CS06 requirements in SSP 30237 are in compliance with the APM requirements.

3.2.7.2.4 Fault Clearing and Protection

The HRF MARES Rack shall be safe and not suffer damage with the transient voltage conditions that are within the limits shown in Figure 3.2.1.3.3-1 of SSP 57000. Loads may be exposed to transient overvoltage conditions during operation of the power system's fault protection components. [SSP 57000, paragraph 3.2.1.3.3]

3.2.7.2.5 Non-Normal Voltage Range

The HRF MARES Rack shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware with the following non-normal voltage characteristics:

A. Maximum overvoltage of + 165 Vdc for 10 sec. [SSP 57000, paragraph 3.2.1.3.4.A]

B. Undervoltage conditions of +102 Vdc for an indefinite period of time. [SSP 57000, paragraph 3.2.1.3.4.B]

3.2.7.2.6 Connectors and Pin Assignments

A. Not applicable to HRF MARES Rack.

B. HRF MARES Rack connectors to UIP shall meet the pin out interfaces of the UIP connector J2 as specified in SSP 57001, paragraph 3.2.1.1. [SSP 57000, paragraph 3.2.2.1.B]

C. HRF MARES Rack connectors to UIP shall meet the requirements of SSQ 21635 or equivalent. [SSP 57000, paragraph 3.2.2.1.C]

D. Not applicable to HRF MARES Rack.

E. HRF MARES Rack connectors to UOP shall meet the pin out interfaces of the UOP connectors J3 and J4 as specified in SSP 57001, paragraph 3.2.1.2. [SSP 57000, paragraph 3.2.2.1.E]

F. HRF MARES Rack connectors to UOP shall meet the requirements of SSQ 21635 or equivalent. [SSP 57000, paragraph 3.2.2.1.F]

3.2.7.2.7 Power Bus Isolation

A. HRF MARES Rack shall provide a minimum of 1-megohm isolation in parallel with not more than 0.03 microfarads of mutual capacitance within internal and external rack EPCE at all times such that no single failure shall cause the independent power buses to be electrically tied. [Mutual capacitance is defined as line-to-line capacitance, exclusive of the Electromagnetic Interference (EMI) input filter.] [SSP 57000, paragraph 3.2.2.2.A]

B. The HRF MARES Rack internal and external EPCE shall not use diodes to electrically tie together independent ISS power bus high side or return lines. These requirements apply to both supply and return lines. [SSP 57000, paragraph 3.2.2.2.B]

ISS provides the capability to support simultaneous use of Main (J1) and Auxiliary (J2) power at each ISPR location (except MPLM). Constrained element level payload operations may occur from individual payload racks that automatically switch to or require simultaneous use of auxiliary power. ISS is required to reserve the maximum auxiliary power needed on that channelized Bus (even when not in use) to prevent Bus overload. For this reason, auxiliary power feeds will nominally be powered off by the module Remote Power Controller (RPC). Specific constraints on the use of auxiliary power will be defined in the payload unique Interface Control Document (ICD).

3.2.7.2.8 Compatibility With Soft Start/Stop Remote Power Controller

HRF MARES Rack shall initialize with the soft start/stop performance characteristics when power is applied, sustained, and removed by control of remote power control switches. The soft start/stop function, active only when the RPC is commanded on or off, is limited to 100 amps/ms, or less, by the RPC output. The response of the soft start/stop function is linear for resistive loads for 1 to 10 ms for USL feeds, 1 to 2 ms for JEM main, and 0.2 ms for JEM 10 amp auxiliary feeds, and 1 to 5 ms for APM feeds between 0 amp and rated current level. [SSP 57000, paragraph 3.2.2.3]

3.2.7.2.9 Surge Current

The HRF MARES Rack surge current at the power inputs shall not exceed the surge current values defined in Figures 3.2.2.4-1 and 3.2.2.4-2 of SSP 57000 when powered from a voltage source with characteristics specified in paragraphs 3.2.7.2 and 3.2.7.2.8, with the exception that the source impedance is considered to be 0.1 ohm. The duration of the surge current shall not exceed 10 ms. These requirements apply to all operating modes and changes including power-up and power-down. [SSP 57000, paragraph 3.2.2.4]

3.2.7.2.10 Reverse Energy/Current

The HRF MARES Rack electrical interface main input power and auxiliary input power shall comply with the requirements defined in Table 3.2.2.5-1 of SSP 57000 for the reverse energy/current into the upstream power source. The HRF MARES Rack interface shall meet either the reverse energy or the reverse current requirement for all environmental conditions specified in this document when powered from a voltage source with characteristics specified in paragraphs 3.2.7.2.1 - 3.2.7.2.5 and 3.2.7.2.8 with a source impedance of 0.1 ohm. [SSP 57000, paragraph 3.2.2.5]

3.2.7.2.11 Remote Power Controllers

A. The HRF MARES Rack shall operate and be compatible with characteristics in Figures 3.2.6-2, 3.2.6-3 and 3.2.6-4 as described in paragraph 3.2.6 located in SSP 57001. [SSP 57000, paragraph 3.2.2.6.1.1.A]

B. Overcurrent protection shall be provided at all points in the system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines. [SSP 57000, paragraph 3.2.2.6.1.1.D]

C. HRF MARES Rack shall provide current limiting overcurrent protection for all internal loads (exclusive of overcurrent protection circuits and devices) drawing power from an interface B power feed. For the purpose of this requirement, internal overcurrent protection circuits and devices are not considered to be loads. [SSP 57000, paragraph 3.2.2.6.1.1.E]

D. HRF MARES Rack circuit protection device trip ratings shall be coordinated with the upstream RPC trip characteristics so that an event that activates protection in a downstream device will not also trip the one upstream. [SSP 57000, paragraph 3.2.2.6.2.1.1]

E. The HRF MARES Rack connected to a UOP shall operate and be compatible with the characteristics in Figure 3.2.6-5 as described in paragraph 3.2.6 located in SSP 57001. [SSP 57000, paragraph 3.2.2.6.1.1.C]

3.2.7.2.11.1 HRF MARES Rack Trip Requirements Summary

A. The HRF MARES Rack PIP shall trip at a current greater than or equal to 10 amps for 19+/-1 msec.

B. The HRF MARES Rack PIP shall limit the fault current to less than 12 amps.

C. The HRF MARES Rack PIP shall achieve current limit within 1 millisecond.

The above three requirements satisfies all trip requirements for the following power interfaces listed in Table 3.2.7.2.11.1-1.

TABLE 3.2.7.2.11.1-1. PIP COMPATIBLE POWER INTERFACES

Type of RPCM	Minimum Trip Level (amps)	Minimum Trip Time (msec)	Current Limiting
APM SSPC 10A lateral	36	1.5	Y
APM SSPC 10A overhead	18	1.5	Y
APM SSPC 25A	36	1.5	Y
APM SSPC 50A	72	1.5	Y
APM SSPC SUP 10A	26.1	1.5	Y
JEM RPCM PDU 10A	17	10	Y
JEM RPCM PDU 25A	42.1	10	Y
JEM RPCM PDU 50A	85	10	Y
US RPCM type I (UOP)	13.2	31.1	Y
US RPCM type II	27.5	31.1	Y
US RPCM type III	54.5	40.1	N
US RPCM type III	95	1.1	N
US RPCM type III	250	0.11	N
US RPCM type IV	65	26	N
US RPCM type V 12A	13.2	31.1	Y
US RPCM type VI	27.5	40.1	N
US RPCM type VI	47.5	1.1	N
US RPCM type VI	125	0.11	N

NOTE: Characteristics are derived from SSP 52051 Volume 1, Tables 3.1.1.5-1, 3.1.1.6.1-1, and 3.1.1.6.2-1.

The PIP does not satisfy power interfaces with trip requirements less than 12 amps. These power interfaces are listed in Table 3.2.7.2.11.1-2.

TABLE 3.2.7.2.11.1-2. PIP NON-COMPATIBLE POWER INTERFACES

Type of RPCM	Minimum Trip Level (amps)	Minimum Trip Time (msec)	Current Limiting
JEM RPCM PDB 1.5A	2.55	10	Y
US RPCM type V 3.5A	3.8	13.2	Y
JEM RPCM PDB 5A	8.5	10	Y
JEM RPCM PDB 10A	12.75	10	Y

NOTE: Characteristics are derived from SSP 52051 Volume 1, Tables 3.1.1.5-1, 3.1.1.6.1-1, and 3.1.1.6.2-1.

3.2.7.2.12 Rack Complex Load Impedances

3.2.7.2.12.1 Interface B

A. The load impedance presented by the HRF MARES Rack to the Main Interface B shall not exceed the bounds defined by Figures 3.2.2.7.1-1 and 3.2.2.7.1-2 of SSP 57000 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the HRF MARES Rack input impedance should not be less than the minimum defined in Figures 3.2.2.7.1-1 and 3.2.2.7.1-2 of SSP 57000. At frequencies where the magnitude component of the HRF MARES Rack input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in these Figures. [SSP 57000, paragraph 3.2.2.7.1.A]

B. The load impedance presented by the HRF MARES Rack to the 1.2 to 1.44 kW interface B shall not exceed the bounds defined by Figure 3.2.2.7.1-3 of SSP 57000 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the HRF MARES Rack input impedance should not be less than the minimum defined in Figure 3.2.2.7.1-3 of SSP 57000. At frequencies where the magnitude component of the HRF MARES Rack input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in this Figure. [SSP 57000, paragraph 3.2.2.7.1.B]

3.2.7.2.12.2 Interface C

The load impedance presented to Interface C shall not exceed the bounds defined by Figure 3.2.2.7.2-1 of SSP 57000 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the EPCE input impedance should not be less than the minimum defined in Figure 3.2.2.7.2-1 of SSP 57000. At frequencies where the magnitude component of the EPCE input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in this Figure. [SSP 57000, paragraph 3.2.2.7.2]

3.2.7.2.13 Large Signal Stability

The HRF MARES Rack shall maintain stability with the ISS EPS interface by damping a transient response to 10 percent of the maximum response amplitude within 1.0 ms, and remaining below 10 percent thereafter under the following conditions:

1. The rise time/fall time (between 10 and 90 percent of the amplitude) of the input voltage pulse is less than 10 microseconds. [SSP 57000, paragraph 3.2.2.8.1]
2. The voltage pulse is to be varied from 100 to 150 μs in duration. [SSP 57000, paragraph 3.2.2.8.2]

NOTE: Figure 3.2.2.8-1 of SSP 57000 is used to clarify the above requirement.

3.2.7.2.14 Deleted

3.2.7.2.15 Electrical Load - Stand Alone Stability

The HRF MARES Rack shall provide local stability by meeting the following conducted susceptibility requirements defined in Paragraph 3.2.7.2.19.4: [SSP 57000, paragraph 3.2.2.10]

A. Paragraph 3.2.2.1 of SSP 30237 (CS01)

B. Paragraph 3.2.2.2 of SSP 30237 (CS02)

C. Paragraph 3.2.2.3 of SSP 30237 (CS06)

3.2.7.2.16 Wire Derating

A. Derating criteria for EPCE at and downstream of the primary circuit protection device(s) in the HRF MARES Rack, as shown in Figure 3.2.3.1-1 of SSP 57000, shall be per National Aeronautics and Space Administration (NASA) Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA-92-038. [SSP 57000, paragraph 3.2.3.1.B]

B. HRF MARES Rack shall use 4 gauge wire for main and auxiliary connections at the UIP. [SSP 57000, paragraph 3.2.3.1.C]

C. Wire derating for wire/cable between EPCE and the UOP shall be in accordance with SSP 30312. [SSP 57000, paragraph 3.2.3.1.A]

3.2.7.2.17 Exclusive Power Feeds

A. The HRF MARES Rack shall receive power only from the UIP dedicated to its rack location. [SSP 57000, paragraph 3.2.3.2.A]

B. Cabling shall not occur between Interface C connected EPCE with Interface B; and/or Interface B connected EPCE with Interface C. [SSP 57000, paragraph 3.2.3.2.B]

3.2.7.2.18 Loss of Power

The HRF MARES Rack shall fail safe in the event of a total or partial loss of power regardless of the availability of Auxiliary power in accordance with NSTS 1700.7B, ISS Addendum. [SSP 57000, paragraph 3.2.3.3]

3.2.7.2.19 Electromagnetic Compatibility

The HRF MARES Rack shall meet the payload provider applicable requirements of SSP 30243, paragraphs 3.1, 3.5, and 3.6.2. [SSP 57000, paragraph 3.2.4]

3.2.7.2.19.1 Electrical Grounding

The HRF MARES Rack shall meet all requirements specified in Section 3 of SSP 30240. [SSP 57000, paragraph 3.2.4.1]

3.2.7.2.19.2 Electrical Bonding

HRF MARES Rack shall interface with the module bond strap per SSP 57001 Hardware ICD Template. Electrical bonding of HRF MARES Rack to Interface B shall be in accordance with SSP 30245 and NSTS 1700.7B, ISS Addendum Sections 213 and 220. [SSP 57000, paragraph 3.2.4.2]

3.2.7.2.19.3 Cable/Wire Design and Control Requirements

HRF MARES Rack cabling shall meet all Cable and Wire Design requirements of SSP 30242. [SSP 57000, paragraph 3.2.4.3]

3.2.7.2.19.4 Electromagnetic Interference

A. HRF MARES Rack shall meet all EMI requirements of SSP 30237. [SSP 57000, paragraph 3.2.4.4]

NOTE: *The alternative use of RS03 stated below applies to radiated susceptibility requirements only.*

B. Alternately, HRF MARES Rack may choose to accept a minimal increase of EMI risk with a somewhat less stringent Electric Field Radiated Susceptibility (RS03) requirement on equipment considered to be non-safety critical to the vehicle and crew. The tailored RS03 requirement, shown below, will hereafter be denoted RS03PL.

FREQUENCY	RS03PL LIMIT (V/m)
14 kHz - 400 MHz	5
400 MHz - 450 MHz	30
450 MHz - 1 GHz	5
1 GHz - 5 GHz	25
5 GHz - 6 GHz	60
6 GHz - 10 GHz	19
13.7 GHz - 15.2 GHz	25

COMMENTS: The less stringent RS03PL limit was developed to envelope the electric fields generated by ISS transmitters and ground-based radars tasked to perform space surveillance and tracking. Ground-based radars that are not tasked to track the ISS and search radars that could momentarily sweep over the ISS are not enveloped by the relaxed RS03PL. For most scientific payloads, the minimal increase of EMI risk for the reduced limits is acceptable. The RS03PL limit does not account for module electric field shielding effectiveness that could theoretically reduce the limits even more. Although shielding effectiveness exists, it is highly dependent on the EPCE location within the module with respect to ISS windows.

3.2.7.2.19.5 Alternating Current Magnetic Fields

The generated Alternating Current (AC) magnetic fields, measured at a distance of 7 centimeters (cm) from the generating equipment, shall not exceed 140 dB above 1 picotesla for frequencies ranging from 30 Hz to 2 kHz, then falling 40 dB per decade to 50 kHz. [SSP 57000, paragraph 3.2.4.6]

3.2.7.2.19.6 Direct Current Magnetic Fields

The generated Direct Current (DC) magnetic fields shall not exceed 170 dB picotesla at a distance of 7 cm from the generating equipment. This applies to electromagnetic and permanent magnetic devices. [SSP 57000, paragraph 3.2.4.7]

3.2.7.2.20 Electrostatic Discharge

Unpowered EPCE and components shall not be damaged by Electrostatic Discharge (ESD) equal to or less than 4,000 V to the case or any pin on external connectors. EPCE that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position. Labeling of EPCE susceptible to ESD up to 15,000 V shall be in accordance with MIL-STD-1686. These voltages are the result of charges that may be accumulated and discharged from ground personnel or crewmembers during equipment installation or removal. [SSP 57000, paragraph 3.2.4.5]

3.2.7.2.21 Corona

HRF MARES Rack electrical and electronic subsystems, equipment, and systems shall be designed to preclude damaging or destructive corona in its operating environment. Guidance for meeting the corona requirement is found in MSFC-STD-531, High Voltage Design Criteria. [SSP 57000, paragraph 3.2.4.8]

3.2.7.2.22 Lightning

The HRF MARES Rack shall meet the lightning induced environment requirement in paragraph 3.2.8.1 of SSP 30243. [SSP 57000, paragraph 3.2.4.9]

3.2.7.3 Command and Data Handling Interface Requirements

3.2.7.3.1 Word/Byte Notations, Types and Data Transmissions

Not applicable to the HRF MARES Rack.

3.2.7.3.2 Consultative Committee for Space Data Systems

Not applicable to the HRF MARES Rack.

3.2.7.3.3 MIL-STD-1553B Low Rate Data Link

Not applicable to the HRF MARES Rack.

3.2.7.3.4 Medium Rate Data Link

Not applicable to the HRF MARES Rack.

3.2.7.3.5 High Rate Data Link

Not applicable to the HRF MARES Rack.

3.2.7.3.6 Maintenance Switch, Smoke Detector, Smoke Indicator, and Fan Interfaces

3.2.7.3.6.1 Rack Maintenance Switch (Rack Power Switch) Interfaces

A. The integrated rack power off command interface characteristics shall be in accordance with Table 3.2.7.3.6.1-1, Bi-Level Data Characteristics (Switch Contact). [SSP 57000, paragraph 3.3.10.1A]

B. The integrated payload rack power cut-off shall be implemented with a manually operated two-position, lever lock switch. [SSP 57000, paragraph 3.3.10.1B]

TABLE 3.2.7.3.6.1-1. BI-LEVEL DATA CHARACTERISTICS (SWITCH CONTACT)

Parameter	Eng. Unit	ISPR
Type Transfer		Floating (Isolation resistance > 1MΩ) DC coupled
Interface (I/F) Resistance (closed)	Ω	< 2.5
I/F Resistance (open)	MΩ	> 1
Open Circuit Leakage Current	μA	0 to 100
Operating Current (closed)	mA	0.2 to 30
Minimum Open Circuit Voltage	V	20

3.2.7.3.6.2 Smoke Detector Interfaces

Not applicable. HRF MARES Rack does not utilize the rack smoke detector.

3.2.7.3.6.3 Rack Maintenance Switch (Rack Power Switch)/Fire Detection Support Interface Connector

A. Integrated rack connector P43 mating requirements to the UIP connector J43 are specified in paragraph 3.2.7.1.4.1, G. [SSP 57000, paragraph 3.3.10.3.A]

B. The integrated rack maintenance switch/Fire Detection Support (FDS) P43 connector shall meet the pin out interfaces of the UIP J43 connector as specified in SSP 57001, paragraph 3.3.6. [SSP 57000, paragraph 3.3.10.3.B]

C. Integrated rack maintenance switch/FDS P43 connector shall meet the requirements of SSQ 21635 or equivalent. [SSP 57000, paragraph 3.3.10.3.C]

3.2.7.4 Payload National Television Standards Committee Video Interface Requirements

Not applicable to HRF MARES Rack.

3.2.7.5 Thermal Control Interface Requirements

Not Applicable to HRF MARES Rack.

3.2.7.6 Vacuum System Requirements

Not applicable to HRF MARES Rack.

3.2.7.7 Pressurized Gas Interface Requirements

Not applicable to HRF MARES Rack.

3.2.7.8 Fluid System Servicer

Not applicable to HRF MARES Rack.

3.2.7.9 Fire Protection Interface Requirements

3.2.7.9.1 Fire Prevention

HRF MARES Rack shall meet the fire prevention requirements specified in NSTS 1700.7B, ISS Addendum, paragraph 220.10a. [SSP 57000, paragraph 3.10.1]

3.2.7.9.2 Payload Monitoring and Detection Requirements

Not applicable to HRF MARES Rack.

3.2.7.9.3 Fire Suppression

Each separate HRF rack and subrack equipment volume, which contains a potential fire source will require fire suppression capabilities. Determination of potential fire sources will be presented to and approved by the Payload Safety Review Panel (PSRP) during the phased safety reviews. Safety fire suppression requirements are specified in NSTS 1700.7B, ISS Addendum, paragraph 220.10c. [SSP 57000, paragraph 3.10.3]

3.2.7.9.4 Labeling

Not applicable to HRF MARES Rack

3.2.7.10 Other Interface Requirements

3.2.7.10.1 Human Research Facility MARES Rack to MARES Interface Requirements

All HRF MARES Rack to MARES interfaces shall comply with the applicable requirements of MARES-0000-SP-103-NTE, HRF Interface Specification.

3.3 DESIGN AND CONSTRUCTION

3.3.1 <u>Materials, Processes, and Parts</u>

3.3.1.1 Materials and Processes

3.3.1.1.1 Materials and Parts Use and Selection

The HRF MARES Rack shall use materials and parts that meet the materials requirements specified in NSTS 1700.7B, ISS Addendum, Section 209. [SSP 57000, paragraph 3.11.1.1]

3.3.1.1.1.1 Russian Materials Usage Agreement

A. Materials shall comply with the "Agreement on the Safe Utilization of Materials in Cargos to be Delivered to ISS by Any Vehicle and Transferred to ISS for Stowage and/or Operation" dated 6/22/2000.

B. Fiberglass cloth tape shall not be used in HRF payloads that may be carried into the ISS Russian segment. (Materials and Processes Technology Branch)

3.3.1.1.2 Commercial Parts

Commercial-Off-the-Shelf (COTS) parts used in the HRF MARES Rack shall meet the materials requirements specified in NSTS 1700.7B, ISS Addendum, Section 209. [SSP 57000, paragraph 3.11.1.1]

3.3.1.1.3 Fluids

Not applicable. HRF MARES Rack does not contain fluids or utilize ISS fluid services.

3.3.1.1.4 Cleanliness

HRF MARES Rack shall conform to Visibly Clean-Sensitive (VC-S) cleanliness requirements as specified in SN-C-0005. [SSP 57000, paragraph 3.11.3]

3.3.1.1.5 Fungus Resistant Material

HRF MARES Rack shall use fungus resistant materials according to the requirements specified in SSP 30233, paragraph 4.2.10. [SSP 57000, paragraph 3.11.4]

3.3.1.2 Sharp Edges and Corners Protection

Payload design within a pressurized module shall protect crewmembers from sharp edges and corners during all crew operations in accordance with NSTS 1700.7, ISS Addendum, paragraph 222.1. [SSP 57000, paragraph 3.12.9.2]

3.3.1.3 Holes

Holes that are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in.) shall be covered. [SSP 57000, paragraph 3.12.9.4]

3.3.1.4 Latches

Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4) exists shall be designed to prevent entrapment of a crewmember's appendage. [SSP 57000, paragraph 3.12.9.4]

3.3.1.5 Screws and Bolts

Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in) shall be capped to protect against sharp threads. [SSP 57000, paragraph 3.12.9.5]

3.3.1.6 Securing Pins

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface. [SSP 57000, paragraph 3.12.9.6]

3.3.1.7 Levers, Cranks, Hooks, and Controls

Levers, cranks, hooks, and controls shall not be located where they can pinch, snag, or cut the crewmembers or their clothing. [SSP 57000, paragraph 3.12.9.7]

3.3.1.8 Burrs

Exposed surfaces shall be free of burrs. [SSP 57000, paragraph 3.12.9.8]

3.3.1.9 Locking Wires

A. Safety wires shall not be used on fasteners, which must be unfastened for on-orbit removal or replacement. [LS-71000, Section 6.4.9.9A]

B. All fracture-critical fasteners as defined in SSP 52005 (Paragraph 5.6, Fastener Requirements, and Appendix B, Glossary of Terms), which must be unfastened for on-orbit removal or replacement, shall be safety cabled or cotter pinned. [LS-71000, Section 6.4.9.9B]

C. Safety wire shall not be used on any on-orbit fasteners. [Payload Safety Review Panel (PSRP)]

3.3.2 Nameplates and Product Marking

3.3.2.1 Equipment Identification

Integrated racks, all (installed in the rack or separately) sub-rack elements, loose equipment, stowage trays, consumables, ORUs, crew accessible connectors and cables, switches, indicators, and controls shall be labeled. Labels are markings of any form [including Inventory Management System (IMS) bar codes] such as decals and placards, which can be adhered, “silk screened,” engraved, or otherwise applied directly onto the hardware. Appendix C of SSP 57000 provides instructions for label and decal design and approval. [SSP 57000, paragraph 3.12.7]

3.3.3 Workmanship

Workmanship shall be in accordance with approved NASA and industry recognized standards. [LS-71000, Section 7.3.1]

3.3.4 Interchangeability

The HRF MARES Rack hardware will be built to flight released drawings. This will ensure interchangeability among each subassembly.

3.3.5 Safety Requirements

3.3.5.1 Electromagnetic Interference Susceptibility for Safety-Critical Circuits

Not applicable to HRF MARES Rack.

3.3.5.2 Payload Electrical Safety

3.3.5.2.1 Mating/Demating of Powered Connectors

EPCE shall meet the electrical safety requirements as defined in NSTS 1700.7 Addendum. Payloads shall comply with the requirements for mating/demating of powered connectors specified in NSTS 18798, MA2-97-093. [SSP 57000, paragraph 3.2.5.1.1]

NOTE: The module can provide one verifiable upstream inhibit which removes voltage from the UIP and UOP connectors. The module design will provide the verification of the inhibit status at the time the inhibit is inserted.

3.3.5.2.2 Safety-Critical Circuits Redundancy

Not applicable to HRF MARES Rack.

3.3.5.2.3 Rack Maintenance Switch (Rack Power Switch)

Each integrated rack shall provide a guarded, two-position, manually operated-switch installed in a visible and accessible location on the front of the rack that removes all power to the integrated rack. [SSP 57000, paragraph 3.2.5.2]

NOTE: Implementation of the rack maintenance switch through the J43 connector as specified in paragraphs 3.2.7.3.6.1 and 3.2.7.3.6.3 meets the intent of this requirement, except in the MPLM. The HRF MARES Rack does not utilize rack resources in the MPLM. Paragraph 3.3.5.2.4 is not required for this implementation.

3.3.5.2.4 Power Switches/Controls

A. Switches/controls performing on/off power functions for all power interfaces shall open (dead-face) all supply circuit conductors except the power return and the equipment grounding conductor while in the power-off position. [SSP 57000, paragraph 3.2.5.3.A]

B. Power-off markings and/or indications shall be used only if all parts, with the exception of overcurrent devices and associated EMI filters, are disconnected from the supply circuit. [SSP 57000, paragraph 3.2.5.3.B]

C. Not applicable to HRF MARES Rack.

3.3.5.2.5 Portable Equipment/Power Cords

A. Non-battery powered portable equipment shall incorporate a three-wire power cord; e.g., a 120 volt supply lead (+), a 120 volt return (-) lead and a safety (green) wire, one end connected to the portable equipment chassis (and all exposed conductive surfaces) and the other end connected to structure at the Ground Fault Circuit Interrupter (GFCI) location through the GFCI interface. A system of double insulation or its equivalent, when approved by NASA, may be used without a ground wire. [SSP 57000, paragraph 3.2.5.5.A]

B. Not applicable to HRF MARES Rack.

3.3.6 <u>Human Engineering</u>

3.3.6.1 Closures or Covers Design Requirements

Not applicable to the HRF MARES Rack.

3.3.6.2 Interior Color

Payloads shall select interior colors in accordance with the requirements in Table 3.2.5.3-1. [SSP 57000, paragraph 3.12.8]

3.3.6.2.1 Rack Mounted Equipment

A. SSP 50008, Rev. A, page 3-4, Table 3.2.7.1, applies to HRF MARES Rack mounted hardware. Front panels for active and stowage drawers meant for installation in HRF MARES Rack shall be off-white, specification #27722 as given in FED-STD-595B, "Federal Standard Colors Used in Government Procurement." [LS-71000, Section 6.4.3.5.1]

B. The finish shall be semi-gloss. [LS-71000, Section 6.4.3.5.1]

C. Not applicable to HRF MARES Rack.

3.3.6.2.2 Stowed/Deployable Equipment

The colors and finishes for stowed and deployable equipment, even if it is normally attached to the rack during use shall be as specified below:

A. COTS equipment that is not repackaged by HRF engineers shall be finished as delivered by the manufacturer. [LS-71000, Section 6.4.3.5.2A]

B. Items that are repackaged by HRF engineers shall be finished using anodic film per MIL-A-8625, Type II, Class 2, Dyed Turquoise. Reference FED-STD-595, Color Specification 15187. [LS-71000, Section 6.4.3.5.2B]

3.3.6.2.3 Colors for Soft Goods

Human factors engineering will provide guidance in the appropriate colors for soft goods, in cooperation with the lead engineers, who will provide data on the available color choices for the specified materials. [LS-71000, Section 6.4.3.5.3]

3.3.6.3 Full Size Range Accommodation

All payload workstations and hardware having crew nominal operations and planned maintenance shall be sized to meet the functional reach limits for the 5th percentile Japanese female and yet shall not constrict or confine the body envelope for the 95th percentile American male as specified in SSP 50005, Section 3. [LS-71000, Section 6.4.2.3]

3.3.6.4 Operation and Control of Payload Equipment

A. Grip Strength

To remove, replace and operate payload hardware, grip strength required shall be less than 254 N (57 lbf). [LS-71000, Section 6.4.1.1A]

B. Linear Forces

Linear forces required to operate or control payload hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 50% of the strength values shown in Figure 3.3.6.4-1 and 60% of the strength values shown in Figure 3.3.6.4-2. [LS-71000, Section 6.4.1.1B]

C. Torque

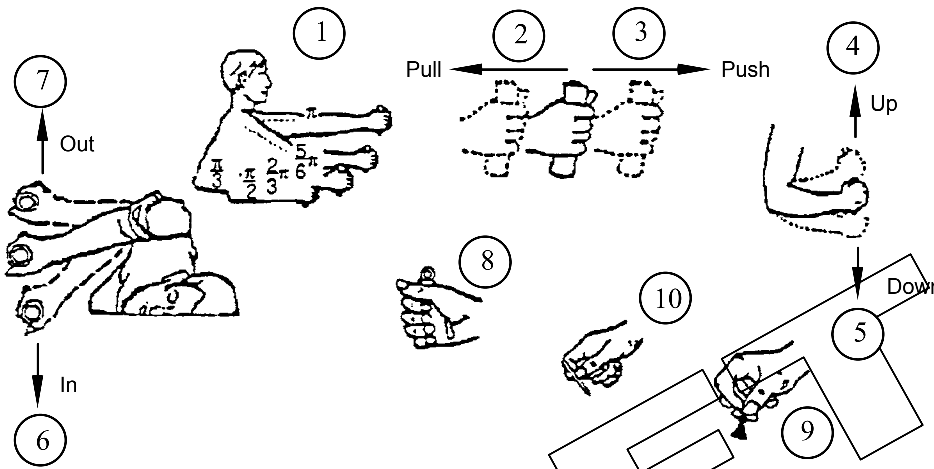
Torque required to operate or control payload hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability shown in Figure 3.3.6.4-3. [LS-71000, Section 6.4.1.1C]

3.3.6.5 Maintenance Operations

Forces required for maintenance of payload hardware and equipment shall be less than the 5th percentile male strength values shown in Figures 3.3.6.4-1, 3.3.6.4-2, 3.3.6.4-3, 3.3.6.5-1, and 3.3.6.5-2. [LS-71000, Section 6.4.1.2]

3.3.6.6 Adequate Clearance

The payloads shall provide clearance for the crew to perform installation, operations and maintenance tasks, including clearance for hand access, tools and equipment used in these tasks. [LS-71000, Section 6.4.2.1]



Arm Strength (N)												
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (rad)	Pull		Push		Up		Down		In		Out	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	89	36	62
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand and thumb-finger strength (N)				
	(8)		(9)	(10)
	Hand Grip			
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold	250	260	60	60
Sustained hold	145	155	35	35

*Elbow angle shown in radians
**L = Left; R = Right

Arm strength (lb)												
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (deg)	Pull		Push		Up		Down		In		Out	
	L	R*	L	R	L	R	L	R	L	R	L	R
180	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	15
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	18	20	17	20	12	17

Hand and thumb-finger strength (lb)				
	(8)		(9)	(10)
	Hand Grip			
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold	56	59	13	13
Sustained hold	33	35	8	8

*Left; R = Right

Figure 3.3.6.4-1. Arm, Hand and Thumb/Finger Strength (5th Percentile Male Data)

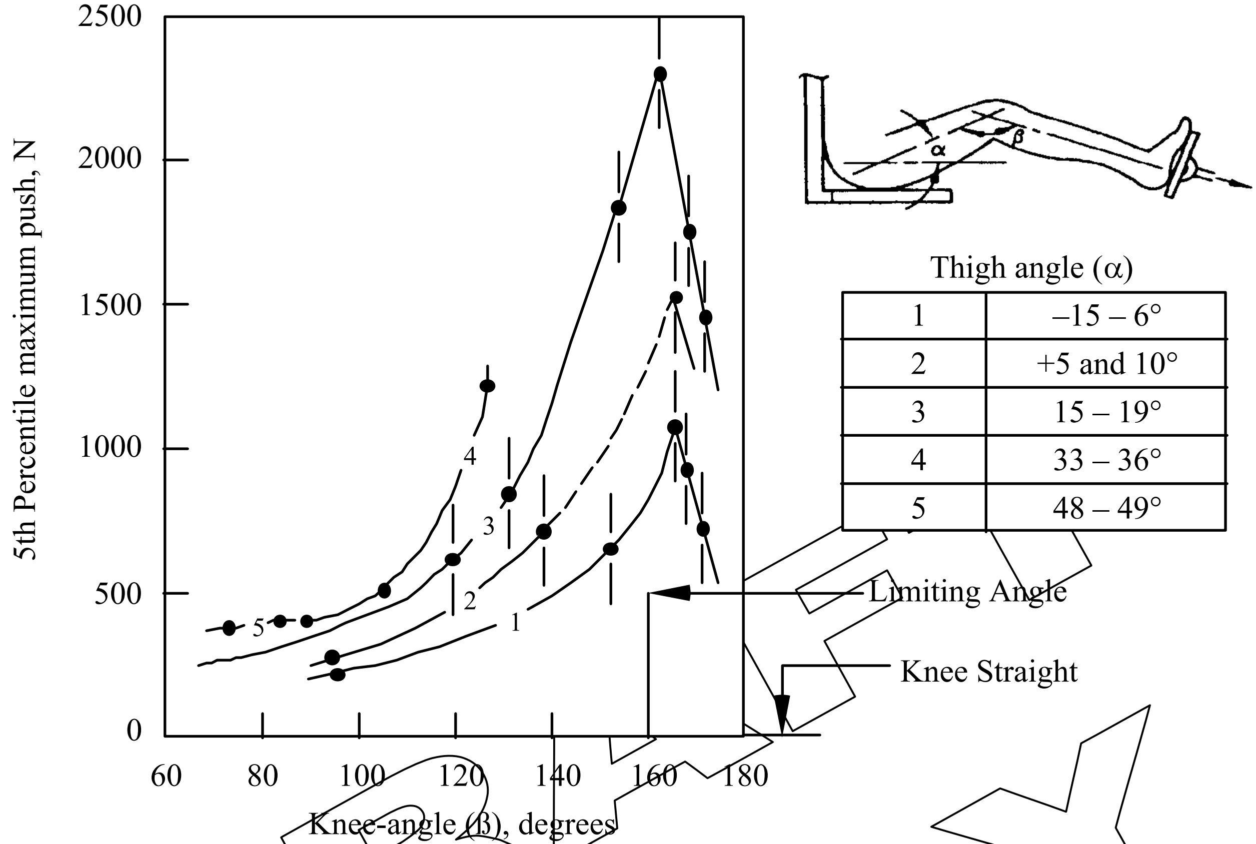


Figure 3.3.6.4-2. Leg Strength at Various Knee and Thigh Angles (5th Percentile Male Data)

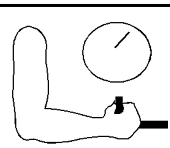
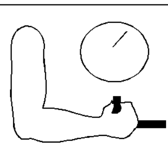
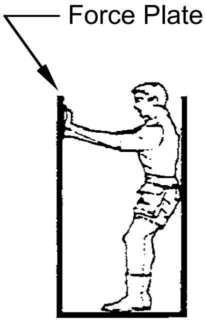
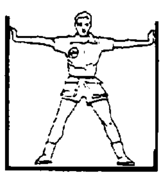
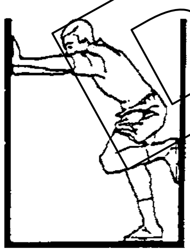
		Unpressurized suit, bare handed	
		Mean	SD
	Maximum torque: Suppination, Nm (lb-in.)	13.73 (121.5)	3.41 (30.1)
	Maximum torque: Pronation, Nm (lb-in.)	17.39 (153.9)	5.08 (45.0)

Figure 3.3.6.4-3. Torque Strength

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	SD
			Both hands	
	100 percent of shoulder height	50	583 (131)	142 (32)
		60	667 (150)	160 (36)
		70	983 (221)	271 (61)
		80	1285 (289)	400 (90)
		90	979 (220)	302 (68)
		100	645 (145)	254 (57)
			Preferred hand	
		50	262 (59)	67 (15)
		60	298 (67)	71 (16)
		70	360 (81)	98 (22)
		80	520 (117)	142 (32)
		90	494 (111)	169 (38)
		100	427 (96)	173 (39)
		Percent of thumb-tip reach*		
	100 percent of shoulder height	50	369 (83)	138 (31)
		60	347 (78)	125 (28)
		70	520 (117)	165 (37)
		80	707 (159)	191 (32)
		90	325 (73)	133 (30)
		Percent of span**		
	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	SD
	50	100	774 (174)	214 (48)
	50	120	778 (175)	165 (37)
	70	120	818 (184)	138 (31)
	Percent of shoulder height		1-g applicable data	

NOTES:

(1) Height of the center of the force plate - 200 mm (8 in) high by 254 mm (10 in) long - upon which force is applied.

(2) Horizontal distance between the vertical surface of the force plate and the opposing vertical surface (wall or footrest, respectively) against which the subject brace themselves.

(3) Thumb-tip reach - distance from backrest to tip of subject's thumb as thumb and fingertips are pressed together.

(4) Span - the maximal distance between a person's fingertips as he extends his arms and hands to each side.

(5) 1-g data.

Figure 3.3.6.5-1. Maximal Static Push Forces

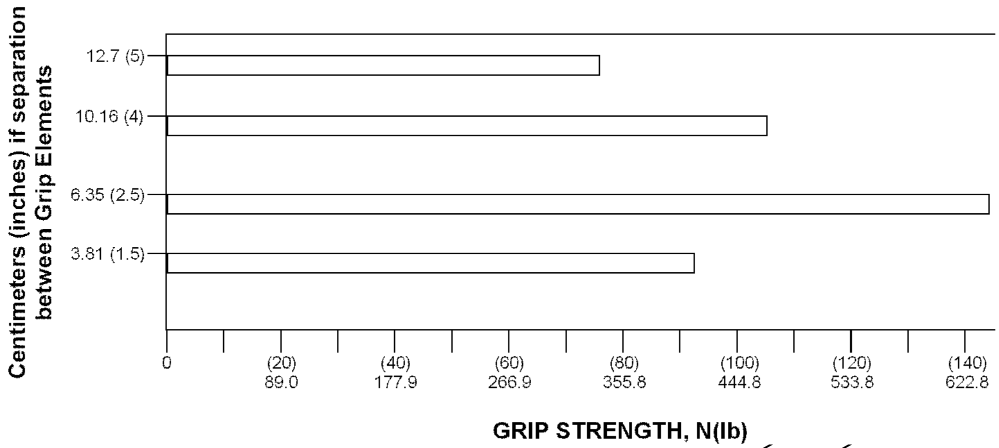


Figure 3.3.6.5-2. Male Grip Strength as a Function of the Separation Between Grip Elements

3.3.6.7 Accessibility

A. Payload hardware shall be geometrically arranged to provide physical and visual access for all payload installation, operations, and maintenance tasks. Payload ORUs should be removable along a straight path until they have cleared the surrounding structure. [LS-71000, Section 6.4.2.2A]

B. IVA clearances for finger access shall be provided as given in Figure 3.3.6.7-1. [LS-71000, Section 6.4.2.2B]

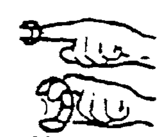
Minimal finger-access to first joint			
Push button access:	Bare hand:	32 mm dia (1.26 in.)	
	Thermal gloved hand:	38 mm dia (1.5 in.)	
Two finger twist access:	Bare hand:	object plus 50 mm (1.97 in.)	
	Thermal gloved hand:	object plus 65 mm (2.56 in.)	

Figure 3.3.6.7-1. Minimum Sizes for Access Openings for Fingers

3.3.6.8 One-Handed Operation

Not applicable to HRF MARES Rack.

3.3.6.9 Continuous/Incidental Contact - High Temperature

When payload surfaces whose temperature exceeds 49 °C (120 °F), which are subject to continuous or incidental contact, are exposed to crewmember's bare skin contact, protective equipment shall be provided to the crew and warning labels shall be provided at the surface site. This also applies to surfaces not normally exposed to the cabin in accordance with the NASA IVA Touch Temperature Safety interpretation letter JSC, MA2-95-048. [SSP 57000, paragraph 3.12.3.2.1]

3.3.6.10 Continuous/Incidental Contact - Low Temperature

Not applicable to HRF MARES Rack.

3.3.6.11 Equipment Mounting

Equipment items used during nominal operations and planned maintenance shall be designed, labeled, or marked to protect against improper installation. [LS-71000, Section 6.4.4.2.1]

3.3.6.12 Drawers and Hinged Panels

Not applicable. HRF MARES Rack contains no drawers or hinged panels used for routine checkout of ORUs.

3.3.6.13 Alignment

Payload hardware having blind mate connectors shall provide guide pins or their equivalent to assist in alignment of hardware during installation. [LS-71000, Section 6.4.4.2.3]

3.3.6.14 Slide-Out Stops

Limit stops shall be provided on slide or pivot mounted HRF MARES Rack hardware, which is required to be pulled out of its installed positions. [LS-71000, Section 6.4.4.2.4]

3.3.6.15 Push-Pull Force

Payload hardware mounted into a capture-type receptacle that requires a push-pull action shall require a force less than 156 N (35 lbf) to install or remove. [LS-71000, Section 6.4.4.2.5]

3.3.6.16 Covers

Not applicable to HRF MARES Rack.

3.3.6.17 Self-Supporting Covers

Not applicable to HRF MARES Rack.

3.3.6.18 Accessibility

It shall be possible to mate/demate individual connectors without having to remove or mate/demate other connectors during nominal operations. [LS-71000, Section 6.4.4.3.2A]

3.3.6.19 Ease of Disconnect

A. Electrical connectors which are mated/demated during nominal operations shall require no more than two turns to disconnect. [SSP 57000, paragraph 3.12.4.3.3A]

B. Electrical connectors which are mated/demated during ORU replacement operations only, shall require no more than six turns to disconnect. [SSP 57000, paragraph 3.12.4.3.B]

3.3.6.20 Indication of Pressure/Flow

Not applicable to HRF MARES Rack.

3.3.6.21 Self Locking

Payload electrical connectors shall provide a self-locking feature. [LS-71000, Section 6.4.4.3.5]

3.3.6.22 Connector Arrangement

A. Space between connectors and adjacent obstructions shall be a minimum of 25 mm (1 inch) for IVA access. [LS-71000, Section 6.4.4.3.6A]

B. Connectors in a single row or staggered rows which are removed sequentially by the crew IVA shall provide 25 mm (1 inch) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence. [LS-71000, Section 6.4.4.3.6B]

3.3.6.23 Arc Containment

Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks. [LS-71000, Section 6.4.4.3.7]

3.3.6.24 Connector Protection

Protection shall be provided for all demated connectors against physical damage and contamination. [LS-71000, Section 6.4.4.3.8]

3.3.6.25 Connector Shape

Payload connectors shall use different connector shapes, sizes or keying to prevent mating connectors when lines differ in content. [LS-71000, Section 6.4.4.3.9]

3.3.6.26 Fluid and Gas Line Connectors

Not applicable to HRF MARES Rack.

3.3.6.27 Alignment Marks or Guide Pins

Mating parts shall have alignment marks in a visible location during mating or guide pins (or their equivalent). [LS-71000, Section 6.4.4.3.11A]

3.3.6.28 Coding

A. Both halves of mating connectors shall display a code or identifier, which is unique to that connection. [LS-71000, Section 6.4.4.3.12A]

B. The labels or codes on connectors shall be located so they are visible when connected or disconnected. [LS-71000, Section 6.4.4.3.12B]

3.3.6.29 Pin Identification

Each pin shall be uniquely identifiable in each electrical plug and each electrical receptacle. At least every 10th pin must be labeled. [LS-71000, Section 6.4.4.3.13]

3.3.6.30 Orientation

Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position. [LS-71000, Section 6.4.4.3.14]

3.3.6.31 Hose/Cable Restraints

A. Payloads shall provide a means to restrain the loose ends of hoses and cables. [LS-71000, Section 6.4.4.3.15A]

B. Conductors, bundles, or cables shall be secured by means of clamps unless they are contained in wiring ducts or cable retractors. [LS-71000, Section 6.4.4.3.15B]

C. Cables should be bundled if multiple cables are running in the same direction and the bundling does not cause EMI. [LS-71000, Section 6.4.4.3.15C]

D. Loose cables [longer than 0.33 meters (1 foot)] shall be restrained as follows [LS-71000, Section 6.4.4.3.15D]:

Length (m)	Restraint Pattern (% of length) tolerances +/- 10%)
0.33-1.00	50
1.00-2.00	33,67
2.00-3.00	20, 40, 60, 80
>3.00	at least each 0.5 meters

3.3.6.32 Non-Threaded Fasteners Status Indication

An indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided. [LS-71000, Section 6.4.4.4.1]

3.3.6.33 Mounting Bolt/Fastener Spacing

Clearance around fasteners to permit fastener hand threading (if necessary) shall be a minimum of 0.5 inches for the entire circumference of the bolt head and a minimum of 1.5 inches over 180 degrees of the bolt head and provide the tool handle sweep as seen in Figure 3.3.6.33-1. Excepted are National Space Transportation System (NSTS) standard middeck lockers or payload-provided hardware with the static envelope dimensions (cross-section) as specified in Figures 3.4.2.1-1, 3.4.2.2-1 and 3.4.2.3-1 of NSTS-21000-IDD-MDK and other similar captive fastener arrangements. [LS-71000, Section 6.4.4.4.2]

3.3.6.34 Multiple Fasteners

When several fasteners are used on one item they shall be of identical type. [LS-71000, Section 6.4.4.4.3]

NOTE: Phillips or Torque-Set fasteners may be used where fastener installation is permanent relative to planned on-orbit operations or maintenance, or where tool-fastener interface failure can be corrected by replacement of the unit containing the affected fastener with a spare unit. [LS-71000, Section 6.4.4.4.3]

3.3.6.35 Captive Fasteners

All fasteners planned to be installed and/or removed on-orbit shall be captive when disengaged. [LS-71000, Section 6.4.4.4.4]

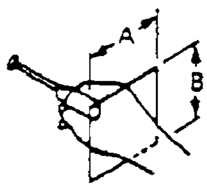
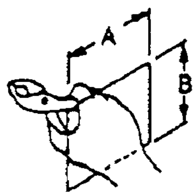
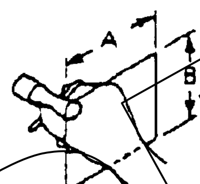
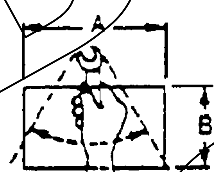
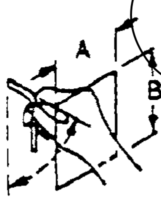
Opening dimensions		Task
	A 117 mm (4.6 in) B 107 mm (4.2 in)	Using common screwdriver with freedom to turn hand through 180°
	A 133 mm (5.2 in) B 115 mm (4.5 in)	Using pliers and similar tools
	A 155 mm (6.1 in) B 135 mm (5.3 in)	Using T-handle wrench with freedom to turn wrench through 180°
	A 203 mm (8.0 in) B 135 mm (5.3 in)	Using open-end wrench with freedom to turn wrench through 62°
	A 122 mm (4.8 in) B 155 mm (6.1 in)	Using Allen-type wrench with freedom to turn wrench through 62°

Figure 3.3.6.33-1. Minimal Clearance for Tool-Operated Fasteners

3.3.6.36 Quick Release Fasteners

A. Quick release fasteners shall require a maximum of one complete turn to operate (quarter - turn fasteners are preferred). [LS-71000, Section 6.4.4.4.5A]

B. Quick release fasteners shall be positive locking in open and closed positions. [LS-71000, Section 6.4.4.4.5B]

3.3.6.37 Threaded Fasteners

Only right-handed threads shall be used. [LS-71000, Section 6.4.4.4.6]

3.3.6.38 Over Center Latches

Not applicable to HRF MARES Rack.

3.3.6.39 Winghead Fasteners

Winghead fasteners shall fold down and be retained flush with surfaces. [LS-71000, Section 6.4.4.4.8]

3.3.6.40 Fastener Head Type

A. Hex type external or internal grip or combination head fasteners shall be used where on-orbit crew actuation is planned, e.g., ORU replacement. [LS 71000, Section 6.4.4.4.9A]

B. If a smooth surface is required, flush or oval head internal hex grip fasteners shall be used for fastening. [LS-71000, Section 6.4.4.4.9B]

C. Slotted fasteners shall not be used to carry launch loads for hard-mounted equipment. Slotted fasteners are allowed in non-structural applications (e.g., computer data connectors, stowed commercial equipment). [LS-71000, Section 6.4.4.4.9C]

3.3.6.41 One-Handed Actuation

Fasteners planned to be removed or installed on-orbit shall be designed and placed so they can be mated/demated using either hand. [LS-71000, Section 6.4.4.4.10]

3.3.6.42 DELETED

3.3.6.43 Access Holes

Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and hand or necessary tool if either is required to replace). [LS-71000, Section 6.4.4.4.12]

3.3.6.44 Controls Spacing Design Requirements

All spacing between controls and adjacent obstructions shall meet the minimum requirements as shown in Figure 3.3.6.44-1, Control Spacing Requirements for Ungloved Operation. [LS-71000, Section 6.4.5.1]

3.3.6.45 Accidental Activation

Requirements for reducing accidental actuation of controls are defined as follows:

3.3.6.45.1 Protective Methods

Payloads shall provide protection against accidental control actuation using one or more of the protective methods listed in sub-paragraphs A through G below. Infrequently used controls (i.e., those used for calibration) should be separated from frequently used controls. Leverlock switches or switch covers are strongly recommended for switches related to mission success. Switch guards may not be sufficient to prevent accidental actuation. [LS-71000, Section 6.4.5.2.1]

NOTE: Displays and controls used only for maintenance and adjustments, which could disrupt normal operations if activated, should be protected during normal operations, e.g., by being located separately or guarded/covered.

A. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements. [LS-71000, Section 6.4.5.2.1A]

B. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier. [LS-71000, Section 6.4.5.2.1B]

C. Not applicable to HRF MARES Rack.

D. Not applicable to HRF MARES Rack.

E. Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required. [LS-71000, Section 6.4.5.2.1E]

F. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation. [LS-71000, Section 6.4.5.2.1F]

G. Provide the controls with a lock to prevent the control from passing through a position without delay when strict sequential actuation is necessary (i.e., the control moved only to the next position, then delayed). [LS-71000, Section 6.4.5.2.1G]

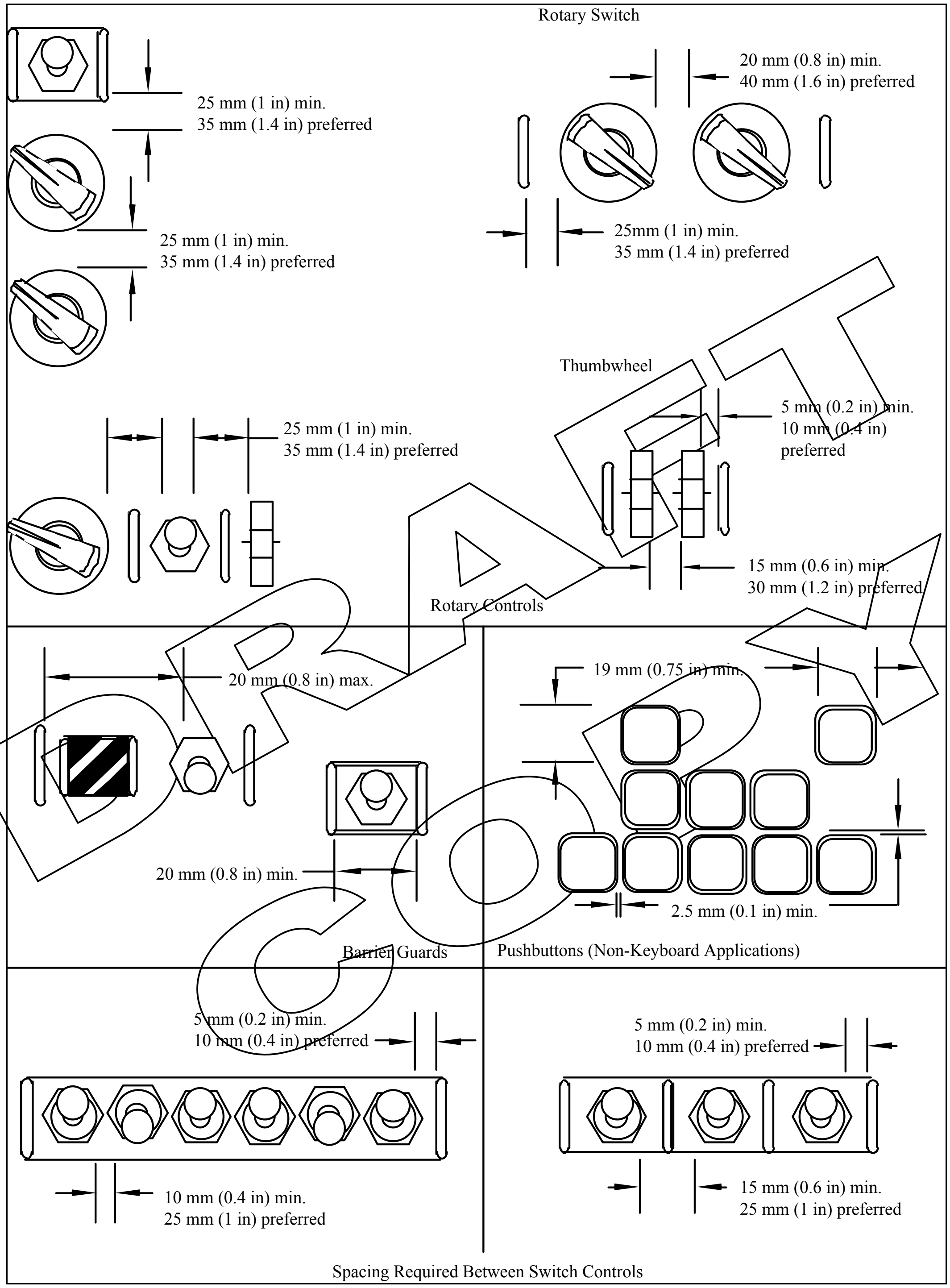


Figure 3.3.6.44-1. Control Spacing Requirements for Ungloved Operation

3.3.6.45.2 Noninterference

Payload provided protective devices shall not cover or obscure other displays or controls. [LS-71000, Section 6.4.5.2.2]

3.3.6.45.3 Dead-Man Controls

Not applicable to HRF MARES Rack.

3.3.6.45.4 Barrier Guards

Barrier guard spacing shall adhere to the requirements for use with the toggle switches, rotary switches, and thumbwheels as shown in Figures 3.3.6.44-1, Control Spacing Requirements for Ungloved Operation and 3.3.6.45.4-1, Rotary Switch Guard. [LS-71000, Section 6.4.5.2.4]

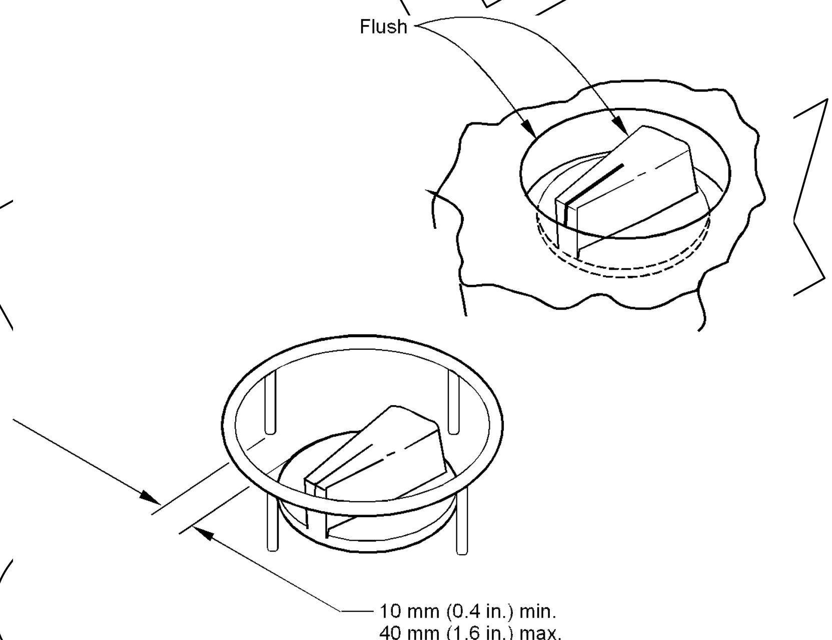


Figure 3.3.6.45.4-1. Rotary Switch Guard

3.3.6.45.5 Recessed Switch Protection

Not applicable to HRF MARES Rack.

3.3.6.46 Position Indication

Not applicable to HRF MARES Rack.

3.3.6.47 Hidden Controls

Not applicable to HRF MARES Rack.

3.3.6.48 Hand Controllers

Not applicable to HRF MARES Rack.

3.3.6.49 Valve Controls

Not applicable to HRF MARES Rack.

3.3.6.50 Toggle Switches

Dimensions for a standard toggle switch shall conform to the values presented in Figure 3.3.6.50-1, Toggle Switches. [LS-71000, Section 6.4.5.4]

3.3.6.51 Restraints and Mobility Aids

Payloads shall be designed such that all installation, operation and maintenance can be performed using standard crew restraints, mobility aids and interfaces as defined in SSP 30257:004. [LS-71000, Section 6.4.6]

3.3.6.51.1 Stowage Drawer Contents Restraints

A. Payload drawer/tray contents shall be restrained in such a way that the items do not float when the drawer/tray is opened or closed. [LS-71000, Section 6.4.6.1A]

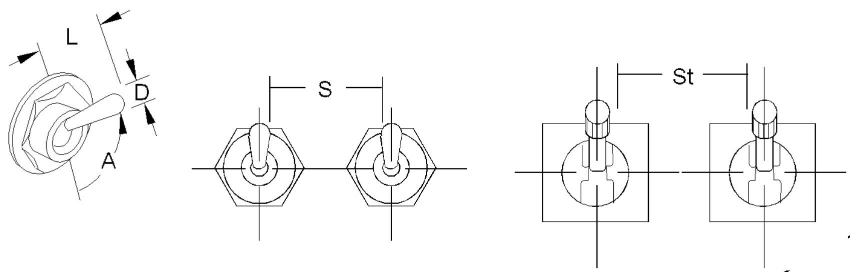
B. Payload drawer/tray contents shall be restrained in a way such that the items do not jam the drawer when the drawer is opened or closed. [LS-71000, Section 6.4.6.1B]

C. Drawer/tray contents shall be restrained in such a way that the contents can be removed/replaced without using a tool. [LS-71000, Section 6.4.6.1C]

3.3.6.51.2 Stowage and Equipment Drawers/Trays

A. All latches, handles, and operating mechanisms shall be designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male to the 5th percentile female. [LS-71000, Section 6.4.6.2A]

B. The design of latches shall be such that their status (locked/unlocked) can be determined through visual inspection. [LS-71000, Section 6.4.6.2B]



	Dimensions		Resistance	
	L Arm Length	D Control Tip	Small Switch	Large Switch
Minimum	13 mm (1/2 in.)	3 mm (1/8 in.)	2.8 N (10 oz)	2.8 N (10 oz.)
Maximum	50 mm (2 in.)	25 mm (1 in.)	4.5 N (16 oz.)	11 N (40 oz.)

	Displacement between positions A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Desired		25°

	Separation S			
	Single finger operation	†	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (3/4 in.)	25 mm (1 in.)	13 mm (1/2 in.)	16 mm (5/8 in.)
Optimum	50 mm (2 in.)	50 mm (2 in.)	25 mm (1 in.)	19 mm (3/4 in.)

† Using a lever lock toggle switch

Figure 3.3.6.50-1. Toggle Switches

3.3.6.51.3 Captive Parts

Payloads and payload equipment shall be designed in such a manner to ensure that all unrestrained parts (e.g., locking pins, knobs, handles, lens covers, access plates, or similar devices) that may be temporarily removed on orbit will be tethered or otherwise held captive. [LS-71000, Section 6.4.6.3]

3.3.6.51.4 Handle and Grasp Area Design Requirements

3.3.6.51.4.1 Handles and Restraints

Not applicable to HRF MARES Rack.

3.3.6.51.4.2 Handle Location/Front Access

Handles and grasp areas shall be placed on the accessible surface consistent with the removal direction. [LS-71000, Section 6.4.6.4.2]

3.3.6.51.4.3 Handle Dimensions

Handles shall be designed in accordance with the minimum applicable dimensions in Figure 3.3.6.51.4.3-1. [LS-71000, Section 6.4.6.4.3]

3.3.6.51.4.4 Non-Fixed Handles Design Requirements

Not applicable to HRF MARES Rack.

3.3.6.52 Electrical Hazards

Electrical equipment other than bioinstrumentation equipment will incorporate the following controls as specified below:

A. If the exposure condition is below the threshold for shock (i.e., below maximum leakage current and voltage requirements as defined within this section), no controls are required. Non-patient equipment with internal voltages not exceeding 30 volts rms or DC nominal (32 volts rms or DC maximum) will contain potentials below the threshold for electrical shock. [LS-71000, Section 6.4.9.1A]

B. If the exposure condition exceeds the threshold for shock, but is below the threshold of the let-go current profile (critical hazard) as defined in Table 3.3.6.52-1, two independent controls (e.g., a safety (green) wire, bonding, insulation, leakage current levels below maximum requirements) shall be provided such that no single failure, event, or environment can eliminate more than one control. [LS-71000, Section 6.4.9.1B]

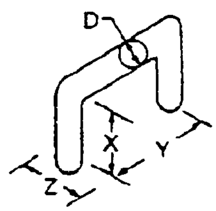
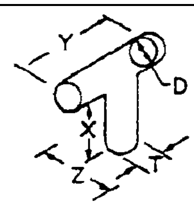
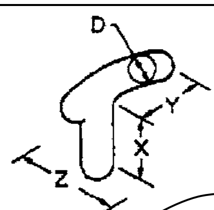
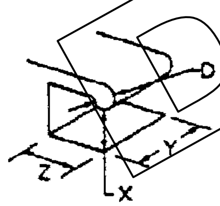
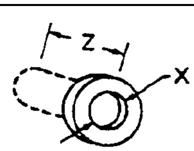
Illustration	Type of handle	Dimensions in mm (in inches) (Bare hand)		
		X	Y	Z
	Two-finger bar One-hand bar Two-hand bar	32 (1-1/4) 48 (1-7/8) 48 (1-7/8)	65 (2-1/2) 111 (4-3/8) 215 (8-1/2)	75 (3) 75 (3) 75 (3)
	T-bar	38 (1-1/2)	100 (4)	75 (3)
	J-bar	50 (2)	100 (4)	75 (3)
	Two-finger recess One-hand recess	32 (1-1/4) 50 (2)	65 (2-1/2) 110 (4-1/4)	75 (3) 90 (3-1/2)
	Finger-tip recess On-finger recess	19 (3/4) 32 (1-1/4)	— —	13 (1/2) 50 (2)
Curvature of handle or edge (DOES NOT PRECLUDE USE OF OVAL HANDLES)	Weight of item up to 6.8 kg (up to 15 lbs) 6.8 to 9.0 kg (15 to 20 lbs) 9.0 to 18 kg (20 to 40 lbs) Over 18 kg (over 40 lbs) T-bar post	Minimum Diameter D = 6 mm (1/4 in) D = 13 mm (1/2 in) D = 19 mm (3/4 in) D = 25 mm (1 in) T = 13 mm (1/2 in)	Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π rad (120°) or more	

Figure 3.3.6.51.4.3-1. Minimum IVA Handle Dimensions for IVA Applications

C. If the exposure condition exceeds both the threshold for shock and the threshold of the let-go current profile (catastrophic hazardous events) as defined in Table 3.3.6.52-1, three independent controls shall be provided such that no combination of two failures, events or environments can eliminate more than two controls. [LS-71000, Section 6.4.9.1C]

D. If two dependent controls are provided, the physiological effect that a crew member experiences as a result of the combinations of the highest internal voltage applied to or generated within the equipment and the frequency and wave form associated with a worst case credible failure shall be below the threshold of the let-go current profile as defined in Table 3.3.6.52-1. [LS-71000, Section 6.4.9.1D]

E. If it cannot be demonstrated that the hazard meets the conditions of Paragraph A, B or C above, three independent hazard controls shall be provided such that no combination of two failures, events or environments can eliminate more than two controls. [LS-71000, Section 6.4.9.1E]

TABLE 3.3.6.52-1. LET-GO CURRENT PROFILE,
THRESHOLD VERSUS FREQUENCY

Frequency (Hertz)	Maximum Total Peak Current (AC + DC components combined) milliamperes
DC	40.0
15	8.5
2000	8.5
3000	13.5
4000	15.0
5000	16.5
6000	17.9
7000	19.4
8000	20.9
9000	22.5
10000	24.3
50000	24.3
(Based on 99.5 Percentile Rank of Adults)	

3.3.6.52.1 Mismatched

A. The design of electrical connectors shall make it impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created. [LS-71000, Section 6.4.9.1.1A]

B. Payload and on-orbit support equipment, wire harnesses, and connectors shall be designed such that no blind connections or disconnections must be made during payload installation, operation, removal, or maintenance on orbit unless the design includes scoop proof connectors or other protective features (NSTS 1700.7B, ISS Addendum, Paragraph 221). [LS-71000, Section 6.4.9.1.1B]

C. For payload equipment, for which mismating or cross-connection may damage ISS-provided equipment, plugs, and receptacles (connectors), shall be selected and applied such that they cannot be mismatched or cross-connected in the intended system as well as adjacent systems. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mismating. [LS-71000, Section 6.4.9.1.1C]

D. For all other payload connections, combinations of identification, keying and clocking, and equipment test and checkout procedures shall be employed at the payload's discretion to minimize equipment risk while maximizing on-orbit operability. [LS-71000, Section 6.4.9.1.1D]

3.3.6.52.2 Overload Protection

3.3.6.52.2.1 Device Accessibility

An overload protective device shall not be accessible without opening a door or cover, except that an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure. [LS-71000, Section 6.4.9.1.2.1]

3.3.6.52.2.2 Extractor -Type Fuse Holder

The design of the extractor-type fuse holder shall be such that the fuse is extracted when the cap is removed. [LS-71000, Section 6.4.9.1.2.2]

3.3.6.52.2.3 Overload Protection Location

Overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on-orbit shall be located where they can be seen and replaced or reset without removing other components. [LS-71000, Section 6.4.9.1.2.3]

3.3.6.52.2.4 Overload Protection Identification

Each overload protector (fuse or circuit breaker) intended to be manually replaced or physically reset on-orbit shall be readily identified or keyed for its proper value. [LS-71000, Section 6.4.9.1.2.4]

3.3.6.52.2.5 Automatic Restart Protection

Controls shall be employed that prevent automatic restarting after an overload-initiated shutdown. [LS-71000, Section 6.4.9.1.2.5]

3.3.6.53 Audio Devices (Displays)

Not applicable to HRF MARES Rack.

3.3.6.54 Egress

All payload egress requirements shall be in accordance with NSTS 1700.7B, ISS Addendum, Paragraph 205. [LS-71000, Section 6.4.9.11]

3.3.7 System Security

Not applicable to HRF MARES Rack.

3.3.8 Design Requirements

3.3.8.1 Structural Design Requirements

3.3.8.1.1 On-orbit Loads

A. HRF MARES Rack with MARES installed shall provide positive margins of safety for on-orbit loads of 0.2 Gs acting in any direction. [SSP 57000, paragraph 3.1.1.3.B]

B Crew Induced Load Requirements

The HRF MARES Rack shall provide positive margins of safety when exposed to the crew induced loads defined in Table 3.3.8.1.1-1, Crew-Induced Loads. [SSP 57000, paragraph 3.1.1.3.D]

TABLE 3.3.8.1.1-1. CREW-INDUCED LOADS

Crew System or Structure	Type of Load	Load	Direction of Load
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Small Knobs	Twist (torsion)	14.9 N-m (11 ft-lbf), limit	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	222.6 N (50 lbf)	Any direction
Rack front panels and any other normally exposed equipment	Load distributed over a 4 inch by 4 inch area	556.4 N (125 lbf), limit	Any direction
Legend: ft = feet, m = meter, N = Newton, lbf = pounds force			

3.3.8.1.2 Safety-Critical Structures Requirements

The HRF MARES Rack shall be designed in accordance with the requirements specified in SSP 52005. [SSP 57000, paragraph 3.1.1.5.A]

3.3.8.1.3 Modal Frequency

The HRF MARES Rack shall have a modal frequency in accordance with SSP 52005 paragraph 5.7, second paragraph for launch and landing, based on rigidly mounting the HRF MARES Rack in the launch configuration. [SSP 57000, paragraph 3.1.1.4.C]

3.3.8.1.4 Launch and Landing Loads

A. HRF MARES Rack shall provide positive margins of safety for launch and landing loading conditions in the MPLM based upon an acceleration environment as defined in SSP 41017 Part 1, paragraph 3.2.1.4.2. [SSP 57000, paragraph 3.1.1.3.A]

B. HRF MARES Rack shall maintain positive margins of safety for the random vibration environment defined in Table 3.3.8.1.4-1. [SSP 57000, paragraph 3.1.1.3E]

TABLE 3.3.8.1.4-1. MPLM RANDOM VIBRATION ENVIRONMENT

Frequency	Level
20 Hz	0.002 g^2/Hz
20-70 Hz	+4.8 dB/oct.
70-150 Hz	0.015 g^2/Hz
150-2000 Hz	-3.7 dB/oct.
2000 Hz	0.0006 g^2/Hz
Composite	2.4 grms

NOTE: Criteria is the same for all directions (X, Y, Z)

C. Components mounted to HRF MARES Rack shall maintain positive margins of safety for the launch and landing conditions in the MPLM. For early design, the acceleration environment defined in Table 3.3.8.1.4-2 will be used. These load factors will be superseded by load factors obtained through ISS-performed Coupled Loads Analysis as described in SSP 52005. [SSP 57000, paragraph 3.1.1.3F]

TABLE 3.3.8.1.4-2. PAYLOAD ISPR MOUNTED EQUIPMENT LOAD FACTORS (EQUIPMENT FREQUENCY 35 HZ)

Liftoff (g)	X ±7.7	Y ±11.6	Z ±9.9
Landing (g)	X ±5.4	Y ±7.7	Z ±8.8

NOTE: Load factors apply concurrently in all possible combinations for each event and are shown in the rack coordinate system defined in SSP 41017, Part 2, Paragraph 3.1.3.

3.3.8.2 Electrical Power Consuming Equipment Design

3.3.8.2.1 Batteries

Not applicable. HRF MARES Rack contains no batteries.

3.4 ACCEPTANCE AND QUALIFICATION REQUIREMENTS

3.4.1 Thermal Environment Compatibility

A. HRF MARES Rack shall operate nominally during exposure to 17 °C to 28 °C (63 °F to 82 °F).

B. HRF MARES Rack shall operate nominally following exposure to 10 °C to 46 °C (50 °F to 115 °F).

3.4.2 Vibration and Sine Sweep

A. MARES Rack shall perform a sinusoidal resonance analysis.

B. MARES Rack shall operate nominally following exposure to flight vibration loads in the launch configuration.

C. The PIP shall operate nominally following vibration at workmanship loads.

3.4.3 Functional Acceptance

HRF MARES Rack shall complete a functional test as outlined in a Task Performance Sheet (TPS) or functional test plan.

3.4.4 Electrical, Electronic and Electromechanical Parts Burn-In

Burn-in screening shall be completed (100%) on all flight hardware (units).

3.4.5 Flammability

All HRF MARES Rack hardware shall meet the flammability test requirements as described in 4.3.5.

3.4.6 Offgassing

All HRF MARES Rack hardware located in inhabitable areas shall meet the offgassing test requirements as described in 4.3.6.

3.4.7 Shock

Not applicable to HRF MARES Rack.

3.4.8 Bench Handling

HRF MARES Rack shall meet the requirements as described in 4.3.8.

3.4.9 Payload Mass

All HRF MARES Rack hardware shall meet the payload mass control requirements as described in 4.3.9.

3.4.10 Electromagnetic Compatibility

All HRF MARES Rack hardware shall meet the EMC control requirements as described in 4.3.10.

3.4.11 Acoustic Noise

Not applicable to HRF MARES Rack.

3.4.12 Safety-Critical Structure Verification

3.4.12.1 Safety-Critical Structure Dimensional Check

Dimensions for all HRF MARES Rack elements identified as safety-critical structures shall comply with design dimensions.

3.4.12.2 Safety-Critical Structure Material Certification

Material composition for all HRF MARES Rack flight unit elements that are identified as safety-critical structures shall be fabricated from the design materials and alloys, and shall be fabricated from materials approved by NASA-JSC.

3.4.13 Software Acceptance

Not applicable to HRF MARES Rack.

3.4.14 Pre-Delivery Acceptance

All HRF MARES Rack equipment shall meet the pre-delivery acceptance (PDA) requirements as described in 4.3.14. [LS-71000, Section 5.4.1.3.2]

3.4.15 Pre-Installation Acceptance

The HRF MARES Rack shall meet the pre-installation acceptance (PIA) requirements as described in 4.3.15. [LS-71000, Section 5.4.1.3.3]

3.5 HUMAN RESEARCH PROGRAM PROGRAM REQUIREMENTS

3.5.1 Safety

The HRF MARES Rack shall meet the applicable requirements of NSTS 1700.7, NSTS 1700.7 ISS Addendum, NSTS/ISS 18798, NSTS/ISS 13830, and KHB 1700.7.

3.5.2 Documentation Requirements

Documentation requirements for HRF MARES Rack shall be as specified in Appendix A of the PRD for HRF, LS-71000. Required items for submittal to NASA are summarized below for convenience.

3.5.2.1 Acceptance Data Package

The contents of the Acceptance Data Package (ADP) shall be based upon SSP 30695, Acceptance Data Package Requirements Specification but shall also include the following:

#	Document	Required for Project		Comments
		Yes	No	
1	Engineering Drawings	X		
2	Inventory of Serialized Components	X		
3	Operating, Maintenance, and Handling Procedures	X		
4	“As run” Test Procedures, Data, and Reports	X		
5	Safety Data	X		
6	Structural Analyses	X		
7	Radioactive Material Data		X	No radioactive material.
8	Calibration Data		X	No calibration data.

1. Engineering Drawings: As-built engineering drawings shall be provided. The drawings shall include the top assembly drawing for each major component and any other drawings necessary to perform receiving inspection and any test or operation to be performed at the destination.

2. Inventory of Serialized Components: A list of “field replaceable” serialized components will be included in the ADP. The list will contain the component part number, component name and component serial number.

3. Operating, Maintenance, and Handling Procedures: Each delivered functional end item shall have a separate manual covering its maintenance, repair, and operation. The manual shall include, but not be limited to, the following (as applicable):

   a. Operational instructions suitable to support operator training and containing a system description and general instructions for operating the equipment.

   b. Any special handling, packing, transportation or storage procedures (i.e., must be stored/transported in a specific orientation, specific environmental conditions, etc.)

   c. A list of special tools, support and facilities equipment and all other materials necessary to perform maintenance.

   d. A schedule chart listing the time at which all maintenance is to be performed. This shall also include inspection for required repair, maintenance, or replacement of parts.

   e. Conditions of environment in which maintenance is to be performed.

   f. Detailed maintenance procedures that describe removal, disassembly, type of maintenance or repair, cleaning, reassemble and reinstallation of all parts or subassemblies. Also included shall be points of inspection and notes of caution.

   g. Illustrated part breakdowns showing the details of the part being worked on.

   h. Schematic and interconnecting wiring diagrams in sufficient detail to enable troubleshooting to be performed down to the replaceable subassembly or printed circuit board level.

   i. Fault analysis will be provided to facilitate maintenance. The repair procedures shall be adequate for testing, checkout, disassembly, cleaning, inspection, repair, reassembly, adjustment, calibration and servicing of the equipment as applicable.

4. "As Run" Test Procedures and Reports: The original "as run" test procedures used for any of the testing required in this Hardware Requirements Document (HRD), along with any associated data and test reports shall be included in the ADP. These procedures shall include quality approval, if applicable, as documented in the Quality Plan.

5. Safety Data: Copies of hazard reports and other safety data prepared or collected as a result of ground and/or flight safety requirements.

6. Structural Analyses: Copies of any structural analyses performed as specified in this HRD or required in the contract with NASA.

7. Radioactive Material Data: If the shipment contains any radioactive material, this section shall include copies of all required data on radioactive material.

8. Calibration Data: This section shall include any calibration or scaling data required to interpret the output signals from or measurements made using the equipment being shipped.

3.5.2.1.1 Acceptance Data Package Statement in Statement of Work

The SOW for procured flight items shall contain a DRD specifying the above ADP contents.

4.0 VERIFICATION PROVISIONS

This section contains the required verification methods for ISS interface certification, science functional acceptance and program qualification, and acceptance. Section 4.1 addresses definitions for terms used herein.

Appendix B contains the applicability matrix for ISS Pressurized Payload Interface Requirements Document requirements. The verification method is also contained in Appendix B. If an alternate verification method is desired, the new verification method must be negotiated in the Interface Control Document.

Appendix C contains the applicability matrix for science functional requirements.

Section 4.3 contains the verification methods for program qualification and acceptance requirements. Appendix D contains the applicability matrices for acceptance and qualification requirements.

The responsibility for the performance of all verification activities is as specified in Appendices B, C and D. All testing described in Appendices B, C and D shall be documented via Task Performance Sheet (TPS) (JSC Form 1225) per JSC Work Instruction NT-CWI-001. Except as otherwise specified in the contract, providers may use their own or any other facility suitable for the performance of the verification requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the verifications set forth in this specification.

4.1 GENERAL

Equipment verification methods are defined as follows:

A. Inspection is a method that determines conformance to requirements by the review of drawings, data or by visual examination of the item using standard quality control methods, without the use of special laboratory procedures.

B. Analysis is a process used in lieu of, or in addition to, other methods to ensure compliance to specification requirements. The selected techniques may include, but not be limited to, engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. Analysis may also include assessing the results of lower level qualification activity. Analysis may be used when it can be determined that (1) rigorous and accurate analysis is possible, (2) test is not cost effective, and (3) verification by inspection is not adequate.

   Verification by similarity is the process of analyzing the specification criteria for hardware configuration and application for an article to determine if it is similar or identical in design, manufacturing process, and quality control to an existing article that has previously been qualified to equivalent or more stringent specification criteria. Special effort will be made to avoid duplication of previous tests from this or similar programs. If the previous application is considered to be similar, but not equal to or greater in severity, additional qualification tests shall concentrate on the areas of new or increased requirements.

C. Demonstration consists of a qualitative determination of the properties of a test article. This qualitative determination is made through observation, with or without special test equipment or instrumentation, which verifies characteristics, such as human engineering features, services, access features, and transportability. Demonstration requirements are normally implemented within a test plan, operations plan, or test procedure.

D. Test is a method in which technical means, such as the use of special equipment, instrumentation, simulation techniques, and the application of established principles and procedures, are used for the evaluation of components, subsystems, and systems to determine compliance with requirements. Test shall be selected as the primary method when analytical techniques do not produce adequate results; failure modes exist which could compromise personnel safety, adversely affect flight systems or payload operation, or result in a loss of mission objectives; or for any components directly associated with Space Station and orbiter interfaces. The analysis of data derived from tests is an integral part of the test program and should not be confused with analysis as defined above.

4.2 RESERVED

4.3 ACCEPTANCE AND QUALIFICATION VERIFICATION METHODS

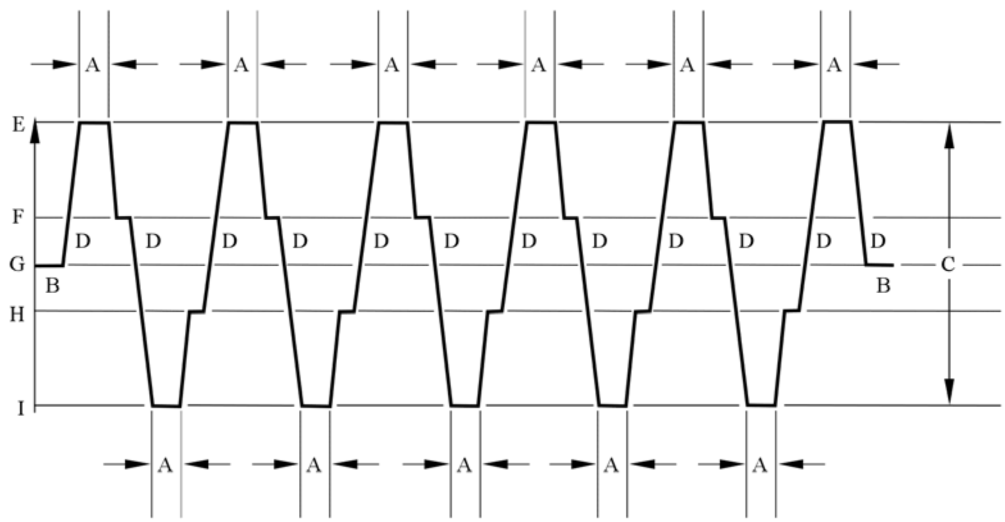
The requirements herein describe specific test requirements for HRF MARES Rack acceptance and qualification. Qualification testing shall only be performed if qualification articles exist for the hardware. If no qualification articles exist for the hardware, analysis may be used to qualify the hardware.

4.3.1 Thermal Cycle Tests

HRF payloads undergoing thermal cycle testing shall be functionally tested at each stable temperature and during transitions. The pass-fail criteria for the functional test and the definition of the functional test will be equipment-unique and shall be defined in the test plan and test procedure. Functional tests shall be conducted on end items prior to, during, and after environmental exposure. [LS-71000, Section 5.4.1.1.6]

4.3.1.1 Qualification Thermal Cycle Test

The Qualification Thermal Cycle Test (QTT) shall be conducted over a temperature range of 61.1 °C (110 °F) centered around the midpoint of the normal operating temperature as defined in Section 3.4.1.A. The Qualification thermal test shall consist of 7½ cycles. One cycle is defined as starting from normal operating temperature, increasing to the maximum high temperature, decreasing to the minimum low temperature and then returning to the normal operating temperature as depicted in Figure 4.3.1.1-1. The complete test is seven and one-half (7½) cycles with 1 hour soaks at each extreme. The hardware will be functionally tested during transitions and at the highest and lowest temperature extremes, consistent with the defined operating temperature range. The hardware shall not be functionally tested at temperatures in excess of the defined operating temperature range. (Hardware shall be unpowered when outside the manufacturer's operating limits.) The specific profile shall be defined in the individual test plans. [LS-71000, Section 5.4.1.1.6.1]

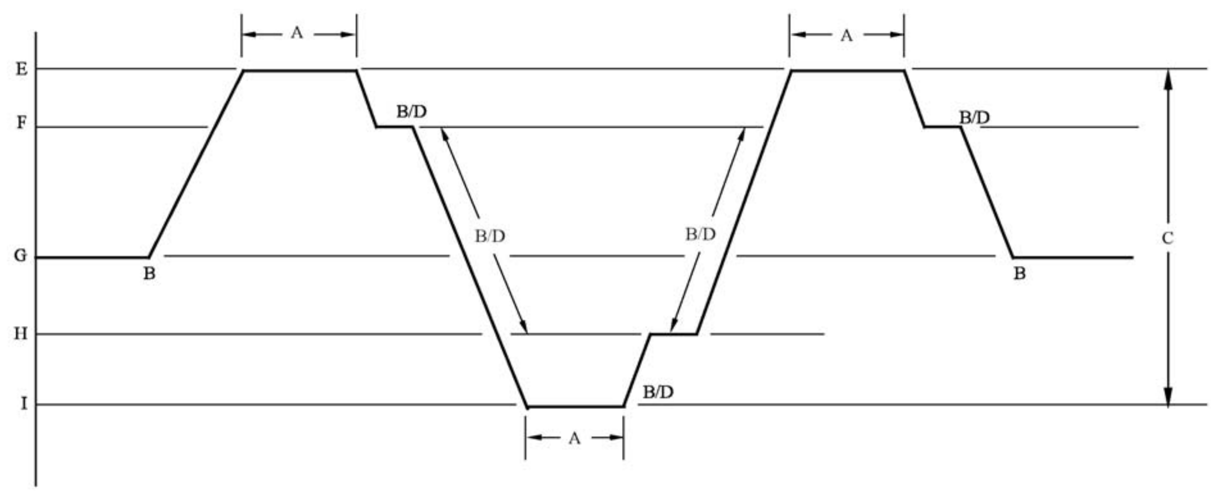


NOTES:
1. A = Time to stabilize equipment temperature plus 1-hour minimum.
2. B = Functional tests to be performed as shown.
3. C = Control temperature range between high and low acceptance test conditions shall be a minimum of 61.11 °C (110 °F). Contractor is to specify tolerances on stable temperature periods.
4. D = Simplified Functional Test. Rate of temperature change during temperature transition shall not be less than 0.55 °C (1 °F)/min. nor greater than 2.22 °C (4 °F)/min.
5. E = Median operational temperature plus 30.56 °C (55 °F).
6. F = Maximum operational temperature.
7. G = Median operational temperature.
8. H = Minimum operational temperature.
9. I = Median operational temperature minus 30.56 °C (55 °F).

Figure 4.3.1.1-1. Qualification Thermal Cycling

4.3.1.2 Acceptance Thermal Cycle Test

An Acceptance Thermal Test (ATT) shall be performed on all flight and flight alternate hardware. The acceptance thermal cycle shall be conducted over a temperature range of 55.6 °C (100 °F) centered around the midpoint of the normal operating temperature as defined in Section 3.4.1.A. The hardware shall be functionally tested before and after the temperature test, at each transition, and at each stable temperature. The hardware shall not be functionally tested at temperatures in excess of the defined operating temperature range. (Hardware shall be unpowered when outside the manufacturer's operating limits.) One cycle is defined as starting from normal operating temperature, increasing to the maximum high temperature, decreasing to the minimum low temperature and then returning to the normal operating temperature as depicted in Figure 4.3.1.2-1. The complete test consists of one and one-half (1½) thermal cycles with 1 hour soaks at each extreme. Minimum temperature sweep shall be 100 °F around the normal operating temperature, and the hardware shall dwell at the temperature extremes for a minimum of 1 hour. [LS-71000, Section 5.4.1.1.6.2]



NOTES:
1. A = Time to stabilize equipment temperature plus 1-hour minimum.
2. B = Functional tests to be performed as shown.
3. C = Control temperature range between high and low acceptance test conditions shall be a minimum of 55.56 °C (100 °F). Contractor is to specify tolerances on temperature periods.
4. D = Simplified functional test (optional). Rate of temperature change during temperature transition shall not be less the 0.55 °C (1 °F)/min. nor greater than 2.22 °C (4 °F)/min.
5. E = Median operational temperature plus 27.78°C (50 °F).
6. F = Maximum operational temperature.
7. G = Median operational temperature.
8. H = Minimum operational temperature.
9. I = Median operational temperature minus 27.78 °C (50 °F).

Figure 4.3.1.2-1. Acceptance Thermal Cycling

4.3.2 Vibration Tests

Sinusoidal Resonance Survey analysis is described in Section 4.3.2.1. Qualification Vibration Analysis (QVA) is described in Section 4.3.2.2.1. Qualification for Acceptance Vibration Test levels are as described in Section 4.3.2.2.2. Acceptance Vibration Test levels are as described in Section 4.3.2.2.3.

4.3.2.1 Sinusoidal Resonance Analysis

The MARES Rack shall be analyzed to determine the fundamental resonance frequencies. [LS-71000, Section 5.4.1.1.2]

4.3.2.2 Random Vibration Test

Hardware subjected to vibration testing shall be functionally tested before and after vibration testing. Hardware expected to operate during launch shall be operating and functionally tested during vibration testing. The pass-fail criteria for the functional test and the definition of the functional test will be equipment unique and shall be defined in the test plan and test procedure for each element. [LS-71000, Section 5.4.1.1.3]

4.3.2.2.1 Qualification Vibration Analysis

QVA certifies the design for launch in the MPLM. The QVA requirement is identical to Section 3.3.8.1.4.A. [LS-71000, Section 5.4.1.1.3.1]

4.3.2.2.2 Qualification for Acceptance Vibration Test

Qualification for Acceptance Vibration Testing (QAVT) determines the number of Acceptance Vibration Tests that may be run on flight units. QAVT shall be run on dedicated qualification test hardware only. The QAVT for HRF equipment shall be performed at a 7.93 g rms composite level over the frequency range and spectral density defined in Table 4.3.2.2.2-1. QAVT shall be conducted at 1.69 times the Acceptance Vibration Test levels. QAVT duration shall be the Acceptance Vibration Testing (AVT) duration multiplied by the number of AVTs for which the hardware is to be qualified. [LS-71000, Section 5.4.1.1.3.2]

TABLE 4.3.2.2.2-1. QUALIFICATION FOR ACCEPTANCE VIBRATION TEST LEVELS

Frequency Range (Hz)	Minimum Power Spectral Density (g^2/Hz)
20	0.017
20 - 80	3 dB/Octave Slope
80 - 350	0.067
350 - 2000	-3 dB/Octave Slope
2000	0.0118
Composite	7.93 g rms

4.3.2.2.3 Acceptance Vibration Test

AVT is used to screen defects in workmanship that cannot be detected by inspection. AVT shall be performed at a 6.1 g rms composite level over the frequency range and minimum AVT levels defined in Table 4.3.2.2.3-1. Vibration duration shall be a minimum of 60 seconds in each of three axes. Functional/continuity tests shall be conducted on components before, during, and after the AVT. [LS-71000, Section 5.4.1.1.3.3]

TABLE 4.3.2.2.3-1. ACCEPTANCE VIBRATION TEST LEVELS

Frequency Range (Hz)	Minimum Power Spectral Density (g^2/Hz)
20	0.01
20 - 80	+3 dB/Octave - Slope
80 - 350	0.04
350 - 2000	-3 dB/Octave - Slope
2000	0.007
Composite	6.1 g rms

4.3.3 <u>Functional Testing</u>

The scope and method of functional testing shall be negotiated between the hardware developer and the quality organization responsible for accepting the hardware. [LS-71000, Section 5.4.1.3.4]

4.3.4 <u>Electrical, Electronic, and Electromechanical Parts Burn-In</u>

The burn-in test may be accomplished at the component or assembly level, and is specified as:

- 72 hrs continuously at room ambient temperature while functioning. During this test, two sets of 5 power cycles each shall be performed. Each set of 5 power cycles shall be completed within a period of 20 minutes. Power cycle timing shall allow sufficient time for the hardware and electronics to reach a steady-state before power to the hardware is restored following power-down.

- 96 hrs continuously at a specified controlled temperature while functioning. During this test, three sets of 5 power cycles each shall be performed. Each set of 5 power cycles shall be completed within a period of 20 minutes. Power cycle timing shall allow sufficient time for the hardware and electronics to reach a steady-state before power to the hardware is restored following power-down.

Full functional tests shall be performed on the experiment hardware before and after the burn-in test. Controlled temperature is defined as 15 °C below the maximum rating of the device with the lowest temperature rating in the article under test. [LS-71000, Section 5.4.1.1.10]

4.3.5 Flammability

Payload materials shall be non-flammable or self-extinguishing per the test criteria of NASA-STD-6001, Test 1, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion. The material shall be evaluated in the worst-case use environment at the worst-case use configuration. When the use of a nonflammable material is not possible, a Material Usage Agreement (MUA) or equivalent shall be submitted to the cognizant NASA center for disposition. If test data does not exist for a material, the experimenter may be asked to provide samples (see NASA-STD-6001, Chapter 4) to a NASA certified test facility Marshall Space Flight Center (MSFC) or White Sands Test Facility (WSTF) for flammability testing. [LS-71000, Section 5.4.1.1.8]

Materials transported or operated in the orbiter cabin or operated in the ISS air lock during Extravehicular Activity (EVA) preparations, shall be tested and evaluated for flammability in the worst-case use environment of 30% oxygen and 10.2 psia. Materials used in all other habitable areas shall be tested and evaluated in the worst-case use environment of 24.1% oxygen and 15.2 psia. [LS-71000, Section 5.4.1.1.8]

4.3.6 Offgassing

All flight hardware located in habitable areas shall be subjected to test and meet the toxicity offgassing acceptance requirements of NASA-STD-6001, Test 7. [LS-71000, Section 5.4.1.1.9]

4.3.7 Shock Test

Not applicable to HRF MARES Rack.

4.3.8 Bench Handling

A bench handling test shall be performed on the qualification unit for all stowed hardware. The bench handling test shall be conducted in accordance with MIL-STD-810, Section 516.4, I-3.8, Procedure VI with the following modifications: Number of actual drops depend upon hardware configuration and will be negotiated with JSC/NT prior to testing. Surfaces, corners, and edges shall be identified in the test procedure. [LS-71000, Section 5.4.1.1.5]

4.3.9 Payload Mass

The HRF MARES Rack weight requirement shall be verified by a demonstration involving measuring the weight of the HRF MARES Rack on the ground prior to launch and an analysis that accounts for attached GSE and any changes during on-orbit operations prior to return of the payload. Verification shall be considered successful when the weight is measured to an accuracy of 2.3 kg (5 lbs) and is less than the specified maximum weight. [SSP 57000, Section 4.3.1.1.4A]

4.3.10 Electromagnetic Compatibility

The HRF MARES Rack shall comply with LS-71016, HRF EMI/EMC Control Plan. [LS-71000, Section 5.4.1.2.1]

4.3.11 Acoustic Noise

Not applicable to HRF MARES Rack.

4.3.12 Safety-Critical Structure Verification

4.3.12.1 Safety-Critical Structure Dimensional Check

All HRF MARES Rack elements identified as safety-critical structures shall be verified to be in accordance with the final design drawing dimensional requirements. [LS-71000, Section 5.4.1.1.11.1]

4.3.12.2 Safety-Critical Structure Material Certification

All HRF MARES Rack elements that are identified as safety-critical structures shall have the components used in those safety-critical structures certified to be fabricated from the materials, and alloys identified in the final design drawing, are to be fabricated from materials approved by NASA-JSC. [LS-71000, Section 5.4.1.1.11.2]

4.3.13 Software Acceptance

Not applicable to HRF MARES Rack.

4.3.14 Pre-Delivery Acceptance

The responsible manufacturing parties shall perform a PDA after the complete fabrication and assembly has been conducted for all Class I deliverable assemblies. This test shall include verification of software interface and operation. The PDA must be completed before hardware certification testing begins. It is a full functional test and inspection that validates that the hardware operates per the design requirements and that it is constructed per released engineering drawings. All PDA tests shall be approved by the hardware's JSC technical monitor and JSC/NT3, as well as the contractor quality engineering (if applicable). The following are standard steps that each PDA test shall contain:

1. Conformance to Drawing. Verify that the hardware conforms to released engineering drawings.

2. No Sharp Edges. Inspect the hardware to verify that there are no sharp edges or corners present.

3. Proper Identifying Markings. Verify that the hardware has the proper part number and serial number (if applicable) on it.

4. Weight and Center of Gravity. Measurements shall be taken of the as-built configuration, per Section 3.2.2.1 of this document.

5. Functional Testing. This is a full functional test and checks all interfaces.

[LS-71000, Section 5.4.1.3.2]

4.3.15 Pre-Installation Acceptance

PIA testing occurs prior to installation in the MPLM.

1. Cleanliness. PIA tests shall include verification that surfaces are to the cleanliness level of Section 3.3.1.1.4 of this document.

2. Functional Testing. PIA functional testing checks rack interfaces prior to installation in the MPLM.

[LS-71000, Section 5.4.1.3.3]

5.0 PREPARATION FOR SHIPMENT

5.1 General

A. The methods of preservation, packaging, and packing used for shipment, together with necessary special control during transportation, shall adequately protect the article(s) from damage or degradation in reliability or performance as a result of the natural and induced environments encountered during transportation and subsequent indoor storage. [LS-71000, Section 9.1A]

B. To reduce program cost, prior to developing a newly designed container, every effort will be made by project participants to use container designs and/or containers available commercially or from Government inventories. If reusable containers are not available, a screening process should be initiated for container availability in the following priority: existing containers, COTS containers, and modified COTS containers. Shipping containers and protective devices will be designed for effective and economical manufacture, procurement, and transportability. [LS-71000, Section 9.1B]

5.2 Packing, Handling and Transportation

A. Packaging, handling, and transportation shall be in accordance with applicable requirements of NHB 6000.1 and referenced documents therein. [LS-71000, Section 9.2A]

B. Documented procedures and physical controls shall be established to ensure that the HRF MARES Rack and individual items of equipment will not be subjected to temperature, shock, and humidity outside the non-operational limits during shipment. [LS-71000, Section 9.2C]

C. The HRF MARES Rack shall be cleaned to the "Visibly Clean Level 1 (Sensitive)" as determined in SN-C-0005, Specification Contamination Control Requirements for the Shuttle Program. [LS-71000, Section 9.2D]

5.3 Preservation and Packing

Preservation and packing shall be in accordance with approved Packaging, Handling, and Transportation Records (PHTRs). [LS-71000, Section 9.3]

5.4 Marking for Shipment

Interior and exterior containers shall be marked and labeled in accordance with NHB 6000.1, including precautionary markings necessary to ensure safety of personnel and facilities, and to ensure safe handling, transport, and storage. Should the individual items of equipment contain any hazardous materials, markings shall also comply with applicable requirements governing packaging and labeling of hazard materials. Packages with reuse capability shall be identified with the words "Reusable Container - Do Not Destroy - Retain for Reuse." NASA Critical Item Labels (Form 1368 series) shall be applied in accordance with NHB 6000.1. [LS-71000, Section 9.4]

5.5 NASA Critical Space Item Label

The NASA Critical Space Item Labels Form 1368 shall be affixed to exterior and interior shipping containers in accordance with NHB 6000.1. [LS-71000, Section 9.5A]

6.0 NOTES

This section contains information of a general or explanatory nature that may be helpful but is not mandatory.

6.1 Definitions

Qualification Test	Test conducted as part of the certification program to demonstrate that the design and performance requirements can be realized under specified conditions.
Acceptance Test	Formal tests conducted to assure that the end item meets specified requirements. Acceptance tests include performance demonstrations and environmental exposures to screen out manufacturing defects, workmanship errors, incipient failures, and other performance anomalies not readily detectable by normal inspection techniques or through ambient functional tests.
Active Air Exchange	Forced convection between two volumes. For example, forced convection between a subrack payload and the internal volume of an integrated rack, or forced convection between a subrack payload and cabin air.
Continuous Noise Source	A significant noise source that exists for a cumulative total of 8 hours or more in any 24-hour period is considered to be a continuous noise source.
Intermittent Noise Source	A significant noise source that exists for a cumulative total of less than 8 hours in a 24-hour period is considered to be an intermittent noise source.
On-Orbit Momentary Protrusions	Payload Obstructions that typically would protrude for a very short time or could be readily eliminated by the crew at any time. Momentary protrusions include only the following: drawer/door/cover replacement or closure.
On-Orbit Permanent Protrusion	A payload hardware item that is not ever intended to be removed.

On-Orbit Protrusions for Keep Alive Payloads	A protrusion that supports and/or provides the uninterrupted resources necessary to run an experiment. On-orbit protrusions for Keep Alive Payloads includes only power/data cables and thermal hoses.
On-Orbit Semi-Permanent Protrusion	A payload hardware item that is typically left in place, but can be removed by the crew with hand operations or standard IVA tools. Example: Standard Interface Rack (SIR) and International Subrack Interface Standards (ISIS) drawer handles, other equipment that does not interfere with crew restraints, and mobility aids.
On-Orbit Temporary Protrusion	A payload item that is typically located in the aisle for experiment purposes only. These items should be returned to their stowed configuration when not being used. Example: Front panel mounted equipment.

APPENDIX A

RESERVED

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.2.1		3.1.1.4A	Mass and Center of Gravity Properties	✓	See ICD	HRF	
3.2.2.2.2.1A	--	3.1.1.7A	On-Orbit Payload Protrusions - Lateral Extension	✓	See ICD	HRF	
3.2.2.2.2.1B	--	3.1.1.7B	On-Orbit Payload Protrusions - Attachment of RMA	✓	See ICD	HRF	
3.2.2.2.2.1.1	--	3.1.1.7.1	On-Orbit Permanent Protrusions	N/A			HRF MARES Rack has no permanent protrusions
3.2.2.2.2.1.2A	--	3.1.1.7.2A	On-Orbit Semi-Permanent Protrusions - SIR and ISIS Drawer Handles	N/A			RID plate requirement which is no longer valid
3.2.2.2.2.1.2B	--	3.1.1.7.2B	On-Orbit Semi-Permanent Protrusions - Other	✓	See ICD	HRF	
3.2.2.2.2.1.2C	--	3.1.1.7.2C	On-Orbit Semi-Permanent Protrusions - Removable	✓	See ICD	HRF	
3.2.2.2.2.1.3A	--	3.1.1.7.3A	On-Orbit Temporary Protrusions - Envelope	✓	See ICD	HRF	
3.2.2.2.2.1.3B	--	3.1.1.7.3B	On-Orbit Temporary Protrusions - Removal	✓	See ICD	HRF	
3.2.2.2.2.1.4	--	3.1.1.7.4	On-Orbit Momentary Protrusions	N/A			HRF MARES Rack has no momentary protrusions
3.2.4A	6.4.4.2.6.3	3.12.4.2.8.4	Maintainability - Unique Tools	N/A			No unique tools to HRF MARES Rack
3.2.4B	6.4.4.3.1	3.12.4.3.1	Maintainability - One-handed Operation	✓	See ICD	HRF	
3.2.4C	6.4.4.3.2B	3.12.4.3.2A2	Maintainability - Connector Mate/Demate	✓	See ICD	HRF	
3.2.4D	6.4.4.3.2C	3.12.4.3.2B	Maintainability - No Damage to Wiring Connectors	✓	See ICD	HRF	

✓ - Requirement is applicable   E - Exception   N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.4E	6.4.4.2.6	3.12.4.2.8	Maintainability - Access to Hardware Items	✓	See ICD	HRF	
3.2.4F	6.4.3.1.2A	3.12.3.1.2A	Maintainability - Built-in Control	N/A			No fluids
3.2.4G	6.4.3.1.2B	3.12.3.1.2B	Maintainability - Access to Filters for Replacement/Cleaning	N/A			No capture elements
3.2.4.1.1	6.4.10	3.12.10	Payload In-flight Maintenance	✓	See ICD	HRF	
3.2.5.1.1.1	6.1.9.1.1	3.9.1.1	Pressure	✓	See ICD	HRF	
3.2.5.1.1.2	6.1.9.1.2	3.9.1.2	Temperature	✓	See ICD	HRF	
3.2.5.1.1.3	6.1.9.1.3	3.9.1.3	Humidity	N/A			No cold sources
3.2.5.1.2.1	6.1.9.2.1	3.9.2.1	Active Air Exchange	N/A			No active air exchange
3.2.5.1.2.2	6.1.9.2.2	3.9.2.2	Oxygen Consumption	N/A			No oxygen consuming equipment
3.2.5.1.2.3	6.1.9.2.3	3.9.2.3	Chemical Releases	✓	See ICD	HRF	HRF MARES Rack has no chemical releases
3.2.5.1.2.4	6.1.5.12	3.5.1.12	Cabin Air Heat Leak	✓	See ICD	HRF	
3.2.5.1.3.1	6.2.9.3.1	3.9.3.1	Instrument Contained or Generated Ionizing Radiation	✓	See ICD	HRF	No radioactive materials or radiation sources
3.2.5.1.3.3	6.1.9.3.3	3.9.3.3	Single Event Effect (SEE) Ionizing Radiation	✓	See ICD	HRF	
3.2.5.1.5A	6.1.1.4B	3.1.1.4B	Pressure Rate of Change - On-orbit	✓	See ICD	HRF	
3.2.5.1.5B	6.1.1.2B	3.1.1.2B	Pressure Rate of Change - MPLM	✓	See ICD	HRF	
3.2.5.1.5C	6.1.1.4H	3.1.1.4K	Pressure Rate of Change - PFE	N/A			HRF MARES Rack has no PFE port
3.2.5.1.5D		3.1.1.4M	Pressure Relief Device	N/A			No relief devices

✓ - Requirement is applicable   E - Exception   N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.5.2	6.4.3.3	3.12.3.3	Acoustic Emission Limits	N/A			HRF MARES Rack contains no noise sources
3.2.5.3A	6.4.3.4A	3.12.3.4A	Lighting Design - Specularity	✓	See ICD	HRF	
3.2.5.3B	6.4.3.4B	3.12.3.4B	Lighting Design - Levels	✓	See ICD	HRF	
3.2.5.3C	6.4.3.4C	3.12.3.4C	Lighting Design - Dimmable	N/A			HRF MARES Rack has no light sources
3.2.5.3D	6.4.3.4D	3.12.3.4D	Lighting Design - Brightness Ratio	N/A			HRF MARES Rack has no glovebox
3.2.5.3E	6.4.3.4E	3.12.3.4E	Lighting Design - Utilize ISS Portable Utility Light (PUL)	N/A			PUL no longer available
3.2.7.1.1A	6.1.1.1A	3.1.1.1A	GSE Interface - Rack Insertion Device	✓	See ICD	HRF	
3.2.7.1.1B	6.1.1.1B	3.1.1.1B	GSE Interface - Rack Shipping Container	✓	See ICD	HRF	
3.2.7.1.1C	6.1.1.1C	3.1.1.1C	GSE Interface - Rack Handling Adapter	✓	See ICD	HRF	
3.2.7.1.1D	6.1.1.1D	3.1.1.1D	GSE Interface - Acceleration	✓	See ICD	HRF	
3.2.7.1.2.1A	6.1.1.2A	3.1.1.2A	MPLM Interface -Attach Points	✓	See ICD	HRF	
3.2.7.1.2.1B	6.1.1.2C	3.1.1.2E	MPLM Interface - Loads	✓	See ICD	HRF	
3.2.7.1.3A	6.1.1.4E	3.1.1.4E	Keep-out Zone	✓	See ICD	HRF	
3.2.7.1.3B	6.1.1.4F	3.1.1.4I	Rack Rotation	✓	See ICD	HRF	
3.2.7.1.3C	6.1.1.4I	3.1.1.4L	Restraints during Rotation	✓	See ICD	HRF	
3.2.7.1.4.1	6.1.1.6.1	3.1.1.6.1	Connector Physical Mate	✓	See ICD	HRF	
3.2.7.1.4.2	6.1.1.6.2	3.1.1.6.2	Umbilical Physical Mate	✓	See ICD	HRF	
3.2.7.2.1.1	6.1.2.1	3.2.1.1.1	Steady-State Voltage - Interface B	✓	See ICD	HRF	
3.2.7.2.1.2	6.1.2.1	3.2.1.1.2	Steady-State Voltage - Interface C	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.7.2.2.1	6.1.2.2.1	3.2.1.2.1	Ripple Voltage/Noise Characteristics - Peak to Peak	✓	See ICD	HRF	
3.2.7.2.2.2	6.1.2.2.2	3.2.1.2.2	Ripple Voltage/Noise Characteristics - Spectrum	✓	See ICD	HRF	
3.2.7.2.3.1	6.1.2.3	3.2.1.3.1	Transient Voltages - Interface B	✓	See ICD	HRF	
3.2.7.2.3.2	6.1.2.3	3.2.1.3.2	Transient Voltages - Interface C	✓	See ICD	HRF	
3.2.7.2.4	6.1.2.4	3.2.1.3.3	Fault Clearing and Protection	✓	See ICD	HRF	
3.2.7.2.5A	6.1.2.5A	3.2.1.3.4A	Non-Normal Voltage Range - Overvoltage	✓	See ICD	HRF	
3.2.7.2.5B	6.1.2.5B	3.2.1.3.4B	Non-Normal Voltage Range - Undervoltage	✓	See ICD	HRF	
3.2.7.2.6B	6.1.2.7B	3.2.2.1B	UIP and UOP Connectors and Pin Assignments - UIP Pin-out	✓	See ICD	HRF	
3.2.7.2.6C	6.1.2.7C	3.2.2.1C	UIP and UOP Connectors and Pin Assignments - UIP Connectors	✓	See ICD	HRF	
3.2.7.2.6E		3.2.2.1E	UIP and UOP Connectors and Pin Assignments - UOP Pin-out	✓	See ICD	HRF	
3.2.7.2.6F		3.2.2.1F	UIP and UOP Connectors and Pin Assignments - UOP Connectors	✓	See ICD	HRF	
3.2.7.2.7A	6.1.2.8A	3.2.2.2A	Power Bus Isolation - Single Failure	✓	See ICD	HRF	
3.2.7.2.7B	6.1.2.8B	3.2.2.2B	Power Bus Isolation - Use of Diodes	✓	See ICD	HRF	
3.2.7.2.8	6.1.2.9	3.2.2.3	Compatibility with Soft Start/Stop RPC	✓	See ICD	HRF	
3.2.7.2.9	6.1.2.10	3.2.2.4	Surge Current	✓	See ICD	HRF	
3.2.7.2.10		3.2.2.5	Reverse Energy/Current	✓	See ICD	HRF	
3.2.7.2.11A		3.2.2.6.1.1A	Remote Power Controllers - Interface B & C	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.7.2.11B		3.2.2.6.1.1D	Remote Power Controllers - Overcurrent Protection	✓	See ICD	HRF	
3.2.7.2.11C		3.2.2.6.1.1E	Remote Power Controllers - Overcurrent Protection Interface B	✓	See ICD	HRF	
3.2.7.2.11D		3.2.2.6.2.1.1	Remote Power Controllers - Trip Rating	✓	See ICD	HRF	
3.2.7.2.11E		3.2.2.6.1.1C	Remote Power Controllers - UOP	✓	See ICD	HRF	
3.2.7.2.12.1A		3.2.2.7.1A	Rack Complex Load Impedances - Interface B (3 kW and 6 kW)	✓	See ICD	HRF	
3.2.7.2.12.1B		3.2.2.7.1B	Rack Complex Load Impedances - Interface B (1.2 kW and 1.44 kW)	✓	See ICD	HRF	
3.2.7.2.12.2		3.2.2.7.2	Rack Complex Load Impedances - Interface C	✓	See ICD	HRF	
3.2.7.2.13		3.2.2.8	Large Signal Stability	✓	See ICD	HRF	
3.2.7.2.15A		3.2.2.10A	Electrical Load-Stand Alone Stability - CS01	✓	See ICD	HRF	
3.2.7.2.15B		3.2.2.10B	Electrical Load-Stand Alone Stability - CS02	✓	See ICD	HRF	
3.2.7.2.15C		3.2.2.10C	Electrical Load-Stand Alone Stability - CS06	✓	See ICD	HRF	
3.2.7.2.16A	6.1.2.17A	3.2.3.1B	Wire Derating - Derating	✓	See ICD	HRF	
3.2.7.2.16B	6.1.2.17B	3.2.3.1C	Wire Derating - AWG	✓	See ICD	HRF	
3.2.7.2.16C		3.2.3.1A	Wire Derating - UOP	✓	See ICD	HRF	
3.2.7.2.17A	6.1.2.18A	3.2.3.2A	Exclusive Power Feeds - UIP	✓	See ICD	HRF	
3.2.7.2.17B	6.1.2.18B	3.2.3.2B	Exclusive Power Feeds - Cabling	✓	See ICD	HRF	
3.2.7.2.18	6.1.2.19	3.2.3.3	Loss of Power	✓	See ICD	HRF	
3.2.7.2.19	6.1.2.20	3.2.4	Electromagnetic Compatibility (EMC)	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.7.2.19.1	6.1.2.20.1	3.2.4.1	Electrical Grounding	✓	See ICD	HRF	
3.2.7.2.19.2	6.1.2.20.2	3.2.4.2	Electrical Bonding	✓	See ICD	HRF	
3.2.7.2.19.3	6.1.2.20.3	3.2.4.3	Cable/Wire Design and Control Requirements	✓	See ICD	HRF	
3.2.7.2.19.4A	6.1.2.20.4	3.2.4.4	Electromagnetic Interference	✓	See ICD	HRF	
3.2.7.2.19.4B	6.1.2.20.4	3.2.4.4	Electromagnetic Interference - Alternative Use of RS03PL	✓	See ICD	HRF	
3.2.7.2.19.5	6.1.2.20.5	3.2.4.6	AC Magnetic Fields	✓	See ICD	HRF	
3.2.7.2.19.6	6.1.2.20.6	3.2.4.7	DC Magnetic Fields	✓	See ICD	HRF	
3.2.7.2.20	6.1.2.21	3.2.4.5	Electrostatic Discharge	✓	See ICD	HRF	
3.2.7.2.21	6.1.2.22	3.2.4.8	Corona	✓	See ICD	HRF	
3.2.7.2.22	6.1.2.23	3.2.4.9	Lightning	✓	See ICD	HRF	
3.2.7.3.1	6.1.3.1	3.3.2	Word/Byte Notations, Types and Data Transmissions	N/A			No notations, types, or transmissions in HRF MARES Rack
3.2.7.3.2	6.1.3.2	3.3.4	Consultative Committee for Space Data Systems (CCSDS)	N/A			No CCSDS data in HRF MARES Rack
3.2.7.3.3	6.1.3.3	3.3.5	MIL-STD-1553B Low Rate Data Link (LRDL)	N/A			No LRDL interfaces in HRF MARES Rack
3.2.7.3.4	6.1.3.4	3.3.6	Medium Rate Data Link (MRDL)	N/A			No MRDL interfaces in HRF MARES Rack
3.2.7.3.5	6.1.3.5	3.3.7	High Rate Data Link (HRDL)	N/A			No HRDL interfaces in HRF MARES Rack

✓ - Requirement is applicable   E - Exception   N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.7.3.6.1A	6.1.3.6.1A	3.3.10.1A	Rack Maintenance Switch Interfaces - Characteristics	✓	See ICD	HRF	
3.2.7.3.6.1B	6.1.3.6.1B	3.3.10.1B	Rack Maintenance Switch Interfaces - Lever-lock switch	✓	See ICD	HRF	
3.2.7.3.6.2	6.1.3.6.2	3.3.10.2	Smoke Detector Interfaces	N/A			No smoke detector in HRF MARES Rack
3.2.7.3.6.3A	6.1.3.6.3A	3.3.10.3A	Rack Maintenance Switch/Fire Detection Support Interface Connector - J43	✓	See ICD	HRF	
3.2.7.3.6.3B	6.1.3.6.3B	3.3.10.3B	Rack Maintenance Switch/Fire Detection Support Interface Connector - Pin-out	✓	See ICD	HRF	
3.2.7.3.6.3C	6.1.3.6.3C	3.3.10.3C	Rack Maintenance Switch/Fire Detection Support Interface Connector - P43	✓	See ICD	HRF	
3.2.7.4	6.1.4	3.4	Payload National Television Standards Committee (NTSC) Video Interface	N/A			No video interfaces
3.2.7.5	6.1.5	3.5	Thermal Control Interface	N/A			No thermal control interfaces
3.2.7.6	6.1.6	3.6	Vacuum System Interface	N/A			No vacuum interfaces
3.2.7.7	6.1.7	3.7	Pressurized Gas Interface	N/A			No pressurized gas interfaces
3.2.7.8	6.1.8	3.8.2	Fluid System Services	N/A			No payload support services interfaces
3.2.7.9.1	6.1.10.1	3.10.1	Fire Prevention	✓	See ICD	HRF	
3.2.7.9.2	6.1.10.2	3.10.2.1-2	Payload Monitoring and Detection Requirements	N/A			No smoke detector or parameter monitoring
3.2.7.9.3.1A-B	6.1.10.2A-B	3.10.3.1A-B	PFE - Small Access Port	N/A			HRF MARES Rack has no PFE ports

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.2.7.9.3.2	6.1.10.3.2	3.10.3.2	Fire Suppression Access Port Accessibility	N/A			HRF MARES Rack has no PFE ports
3.2.7.9.3.3	6.1.10.3.3	3.10.3.3	Fire Suppressant Distribution	N/A			HRF MARES Rack has no PFE ports
3.2.7.9.4A	6.1.10.4A	3.10.4A	Labeling - PFE Port	N/A			HRF MARES Rack has no PFE ports
3.2.7.9.4B	6.1.10.4B	3.10.4B	Labeling - Fire Detection LED	N/A			HRF MARES Rack has no fire detection Light-Emitting Diode (LED)
3.3.1.1.1	6.1.11.1	3.11.1	Materials and Parts Use and Selection	✓	See ICD	HRF	PSRP Approval
3.3.1.1.2	6.1.11.1.1	3.11.1.1	Commercial Parts	✓	See ICD	HRF	PSRP Approval
3.3.1.1.3A-C	6.1.11.2A-C	3.11.2A-C	Fluids	N/A			No fluids in HRF MARES Rack
3.3.1.1.4	6.1.11.3	3.11.3	Cleanliness	✓	See ICD	HRF	Inspect drawings, TPS
3.3.1.1.5	6.1.11.4	3.11.4	Fungus Resistant Material	✓	See ICD	HRF	Material Cert
3.3.1.2	6.4.9.2	3.12.9.2	Sharp Edges and Corner Protection	✓	See ICD	HRF	PSRP Approval
3.3.1.3	6.4.9.3	3.12.9.3	Holes	✓	See ICD	HRF	
3.3.1.4	6.4.9.4	3.12.9.4	Latches	✓	See ICD	HRF	
3.3.1.5	6.4.9.5	3.12.9.5	Screws and Bolts	✓	See ICD	HRF	
3.3.1.6	6.4.9.6	3.12.9.6	Securing Pins	✓	See ICD	HRF	
3.3.1.7	6.4.9.7	3.12.9.7	Levers, Cranks, Hooks, and Controls	✓	See ICD	HRF	
3.3.1.8	6.4.9.8	3.12.9.8	Burrs	✓	See ICD	HRF	
3.3.1.9A	6.4.9.9A	3.12.9.9A-B	Locking Wires - Safety Wires	✓	See ICD	HRF	
3.3.1.9B	6.4.9.9B	3.12.9.9A-B	Locking Wires - Fracture Critical Fasteners	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.2.1	6.4.7	3.12.7	Equipment Identification	✓	See ICD	HRF	
3.3.5.1	6.1.2.24	3.2.4.10	EMI Susceptibility for Safety-Critical Circuits	N/A			No safety-critical circuits
3.3.5.2.1	6.1.2.25.1	3.2.5.1.1	Mating/Demating of Powered Connectors	✓	See ICD	HRF	
3.3.5.2.2	6.1.2.25.2	3.2.5.1.2	Safety-Critical Circuits Redundancy	N/A			No safety-critical circuits
3.3.5.2.3	6.1.2.25.3	3.2.5.2	Rack Maintenance Switch (Rack Power Switch)	✓	See ICD	HRF	
3.3.5.2.4A	6.1.2.25.4A	3.2.5.3A	Power Switches/Controls - Open Supply Circuit Conductors	✓	See ICD	HRF	
3.3.5.2.4B	6.1.2.25.4B	3.2.5.3B	Power Switches/Controls - Power-off Markings/Indications	✓	See ICD	HRF	
3.3.5.2.4C	6.1.2.25.4C	3.2.5.3C	Power Switches/Controls - Supply Circuit not Completely Disconnected	N/A			No standby mode
3.3.5.2.5A	6.3.2.10.5B	3.2.5.5A	Portable Equipment/Power Cords - Three-wire power cord	✓	See ICD	HRF	
3.3.5.2.5B	6.3.2.10.5B	3.2.5.5B	Portable Equipment/Power Cords - Fault current	N/A			No credible fault path to crew
3.3.6.1	6.4.3.1.1	3.12.3.1.1	Closures or Covers Design Requirements	N/A			HRF MARES Rack designed for routine cleaning
3.3.6.2		3.12.8	Color	✓	See ICD	HRF	
3.3.6.3	6.4.2.3	3.12.2.3	Full Size Range Accommodation	✓	See ICD	HRF	
3.3.6.4A	6.4.1.1A	3.12.1A1	Grip Strength	✓	See ICD	HRF	
3.3.6.4B	6.4.1.1B	3.12.1A2	Linear Forces	✓	See ICD	HRF	
3.3.6.4C	6.4.1.1C	3.12.1A3	Torque	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.6.5	6.4.1.2	3.12.1B	Maintenance Operations	✓	See ICD	HRF	
3.3.6.6	6.4.2.1	3.12.2.1	Adequate Clearance	✓	See ICD	HRF	
3.3.6.7A	6.4.2.2A	3.12.2.2A	Accessibility - Geometric Arrangement	✓	See ICD	HRF	
3.3.6.7B	6.4.2.2B	3.12.2.2B	Accessibility - Access Openings for Fingers	✓	See ICD	HRF	
3.3.6.8	6.4.3.1.3	3.12.3.1.5	One-Handed Operation	N/A			No cleaning supplies for HRF MARES Rack
3.3.6.9	6.4.3.2.1	3.12.3.2.1	Continuous/Incidental Contact - High Temperature	✓	See ICD	HRF	
3.3.6.10	6.4.3.2.2	3.12.3.2.2	Continuous/Incidental Contact - Low Temperature	N/A			HRF MARES Rack serves no cooling functions.
3.3.6.11	6.4.4.2.1	3.12.4.2.1	Equipment Mounting	✓	See ICD	HRF	
3.3.6.12A-B	6.4.4.2.2A-B	3.12.4.2.2	Drawers and Hinged Panels	N/A			HRF MARES Rack has no ORUs for routine checkout.
3.3.6.13	6.4.4.2.3	3.12.4.2.5	Alignment	✓	See ICD	HRF	
3.3.6.14	6.4.4.2.4	3.12.4.2.6	Slide-Out Stops	✓	See ICD	HRF	
3.3.6.15	6.4.4.2.5	3.12.4.2.7	Push-Pull Force	✓	See ICD	HRF	
3.3.6.16A-B	6.4.4.2.6.1A-B	3.12.4.2.8.1A-B	Covers - sliding or hinged cap or door	N/A			No physical access required
3.3.6.17	6.4.4.2.6.2	3.12.4.2.8.2	Self-Supporting Covers	N/A			No physical access required
3.3.6.18	6.4.4.3.2A	3.12.4.3.2A1	Accessibility	✓	See ICD	HRF	
3.3.6.19A	6.4.4.3.3A	3.12.4.3.3A	Ease of Disconnect - Nominal Operations	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.6.19B	6.4.4.3.3B	3.12.4.3.3B	Ease of Disconnect - ORU Replacement Operations	✓	See ICD	HRF	
3.3.6.20	6.4.4.3.4	3.12.4.3.4	Indication of Pressure/Flow	N/A			No fluids
3.3.6.21	6.4.4.3.5	3.12.4.3.5	Self Locking	✓	See ICD	HRF	
3.3.6.22A	6.4.4.3.6A	3.12.4.3.6A	Connector Arrangement - Space between Connectors and Adjacent Obstructions	✓	See ICD	HRF	
3.3.6.22B	6.4.4.3.6B	3.12.4.3.6B	Connector Arrangement - Space between Connectors in a Row	✓	See ICD	HRF	
3.3.6.23	6.4.4.3.7	3.12.4.3.7	Arc Containment	✓	See ICD	HRF	
3.3.6.24	6.4.4.3.8	3.12.4.3.8	Connector Protection	✓	See ICD	HRF	
3.3.6.25	6.4.4.3.9	3.12.4.3.9	Connector Shape	✓	See ICD	HRF	
3.3.6.26	6.4.4.3.10	3.12.4.3.10	Fluid and Gas Line Connectors	N/A			No fluid/gas lines
3.3.6.27	6.4.4.3.11A	3.12.4.3.11A	Alignment Marks or Guide Pins	✓	See ICD	HRF	
3.3.6.28A	6.4.4.3.12A	3.12.4.3.12A	Coding - Unique to Connection	✓	See ICD	HRF	
3.3.6.28B	6.4.4.3.12B	3.12.4.3.12B	Coding - Visible	✓	See ICD	HRF	
3.3.6.29	6.4.4.3.13	3.12.4.3.13	Pin Identification	✓	See ICD	HRF	
3.3.6.30	6.4.4.3.14	3.12.4.3.14	Orientation	✓	See ICD	HRF	
3.3.6.31A	6.4.4.3.15A	3.12.4.3.15A	Hose/Cable Restraints - Loose Ends	✓	See ICD	HRF	
3.3.6.31B	6.4.4.3.15B	3.12.4.3.15B	Hose/Cable Restraints - Clamps	✓	See ICD	HRF	
3.3.6.31D	6.4.4.3.15D	3.12.4.3.15D	Hose/Cable Restraints - Loose Cables	✓	See ICD	HRF	
3.3.6.32	6.4.4.4.1	3.12.4.4.1	Non-Threaded Fasteners Status Indication	✓	See ICD	HRF	
3.3.6.33	6.4.4.4.2	3.12.4.4.2	Mounting Bolt/Fastener Spacing	✓	See ICD	HRF	
3.3.6.34	6.4.4.4.3	3.12.4.4.4A	Multiple Fasteners	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.6.35	6.4.4.4.4	3.12.4.4.5	Captive Fasteners	✓	See ICD	HRF	
3.3.6.36A	6.4.4.4.5A	3.12.4.4.6A	Quick Release Fasteners - One turn max	✓	See ICD	HRF	
3.3.6.36B	6.4.4.4.5B	3.12.4.4.6B	Quick Release Fasteners - Positive Locking	✓	See ICD	HRF	
3.3.6.37	6.4.4.4.6	3.12.4.4.7	Threaded Fasteners	✓	See ICD	HRF	
3.3.6.38A-C	6.4.4.4.7A-C	3.12.4.4.8A-C	Over Center Latches	N/A			No over-center latches
3.3.6.39	6.4.4.4.8	3.12.4.4.9	Winghead Fasteners	✓	See ICD	HRF	
3.3.6.40A	6.4.4.4.9A	3.12.4.4.11A	Fastener Head Type - On-Orbit Crew Actuation	✓	See ICD	HRF	
3.3.6.40B	6.4.4.4.9B	3.12.4.4.11B	Fastener Head Type - Smooth Surface	✓	See ICD	HRF	
3.3.6.40C	6.4.4.4.9C	3.12.4.4.11C	Fastener Head Type - Slotted Fasteners	✓	See ICD	HRF	
3.3.6.41	6.4.4.4.10	3.12.4.4.12	One-Handed Actuation	✓	See ICD	HRF	
3.3.6.43	6.4.4.4.12	3.12.4.4.14	Access Holes	✓	See ICD	HRF	
3.3.6.44	6.4.5.1	3.12.5.1	Controls Spacing Design Requirements	✓	See ICD	HRF	
3.3.6.45.1A-G	6.4.5.2.1A-G	3.12.5.2.1A-G	Protective Methods	✓	See ICD	HRF	
3.3.6.45.2	6.4.5.2.2	3.12.5.2.2	Noninterference	✓	See ICD	HRF	
3.3.6.45.3	6.4.5.2.3	3.12.5.2.3	Dead-Man Controls	N/A			No dead-man controls
3.3.6.45.4	6.4.5.2.4	3.12.5.2.4	Barrier Guards	✓	See ICD	HRF	
3.3.6.45.5	6.4.5.2.5	3.12.5.2.5	Recessed Switch Protection	N/A			No recessed or rotary switches
3.3.6.46	6.4.5.2.7	3.12.5.2.7	Position Indication	N/A			No covers in design
3.3.6.47	6.4.5.2.8	3.12.5.2.8	Hidden Controls	N/A			No hidden controls
3.3.6.48	6.4.5.2.9	3.12.5.2.9	Hand Controllers	N/A			No hand controllers
3.3.6.49A-E	6.4.5.3A-E	3.12.5.3A-E	Valve Controls	N/A			No valves in design

✓ - Requirement is applicable   E - Exception   N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.6.50	6.4.5.4	3.12.5.4	Toggle Switches	✓	See ICD	HRF	
3.3.6.51	6.4.6	3.12.6	Restraints and Mobility Aids	✓	See ICD	HRF	
3.3.6.51.1A	6.4.6.1A	3.12.6.1A	Stowage Drawer Contents - Restraints	✓	See ICD	HRF	
3.3.6.51.1B	6.4.6.1B	3.12.6.1B	Stowage Drawer Contents - Restraints	✓	See ICD	HRF	
3.3.6.51.1C	6.4.6.1C	3.12.6.1C	Stowage Drawer Contents - Restraints	✓	See ICD	HRF	
3.3.6.51.2A	6.4.6.2A	3.12.6.2A	Stowage and Equipment Drawers/Trays	✓	See ICD	HRF	
3.3.6.51.2B	6.4.6.2B	3.12.6.2B	Stowage and Equipment Drawers/Trays	✓	See ICD	HRF	
3.3.6.51.3	6.4.6.3	3.12.6.3	Captive Parts	✓	See ICD	HRF	
3.3.6.51.4.1	6.4.6.4.1	3.12.6.4.1	Handles and Restraints	N/A			All portable equipment can be grasped with one hand
3.3.6.51.4.2	6.4.6.4.2	3.12.6.4.3	Handle Location/Front Access	✓	See ICD	HRF	
3.3.6.51.4.3	6.4.6.4.3	3.12.6.4.4	Handle Dimensions	✓	See ICD	HRF	
3.3.6.51.4.4A-C	6.4.6.4.4A-C	3.12.6.4.5A-C	Non-Fixed Handles Design Requirements - Stop Position	N/A			No non-fixed handles
3.3.6.52B	6.4.9.1B	3.12.9.1B	Electrical Hazards - Exposure hazard exceeds threshold for shock	✓	See ICD	HRF	
3.3.6.52C	6.4.9.1C	3.12.9.1C	Electrical Hazards - Exposure hazard exceeds threshold for shock and threshold of let-go profile	✓	See ICD	HRF	
3.3.6.52D	6.4.9.1D	3.12.9.1D	Electrical Hazards - Two dependent controls provided	✓	See ICD	HRF	
3.3.6.52E	6.4.9.1E	3.12.9.1E	Electrical Hazards - Three independent hazard controls	✓	See ICD	HRF	
3.3.6.52.1A	6.4.9.1.1A	3.12.9.1.1	Mismatched - Reversed Connection	✓	See ICD	HRF	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable

APPENDIX B

INTERNATIONAL SPACE STATION (ISS) PRESSURIZED PAYLOAD INTERFACE REQUIREMENTS DOCUMENT VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	SSP 57000 Section	Requirement	Applicable	Verification Method	Responsibility	Comments
3.3.6.52.1B	6.4.9.1.1B	3.12.9.1.1	Mismatched - Blind Connections	✓	See ICD	HRF	
3.3.6.52.1C	6.4.9.1.1C	3.12.9.1.1	Mismatched - Mismating	✓	See ICD	HRF	
3.3.6.52.1D	6.4.9.1.1D	3.12.9.1.1	Mismatched - Minimizing Equipment Risk	✓	See ICD	HRF	
3.3.6.52.2.1	6.4.9.1.2.1	3.12.9.1.4.1	Device Accessibility	✓	See ICD	HRF	
3.3.6.52.2.2	6.4.9.1.2.2	3.12.9.1.4.2	Extractor-Type Fuse Holder	✓	See ICD	HRF	
3.3.6.52.2.3	6.4.9.1.2.3	3.12.9.1.4.3	Overload Protection Location	✓	See ICD	HRF	
3.3.6.52.2.4	6.4.9.1.2.4	3.12.9.1.4.4	Overload Protection Identification	✓	See ICD	HRF	
3.3.6.52.2.5	6.4.9.1.2.5	3.12.9.1.4.5	Automatic Restart Protection	✓	See ICD	HRF	
3.3.6.53	6.4.9.10	3.12.9.10	Audio Displays	N/A			No audio displays
3.3.6.54	6.4.9.11	3.12.9.12	Egress	✓	See ICD	HRF	
3.3.8.1.1A	6.1.1.3B	3.1.1.3B	Structural Design Requirements - Positive Safety Margins for On-orbit Loads	✓	See ICD	HRF	
3.3.8.1.1B	6.1.1.3D	3.1.1.3D	Structural Design Requirements - Crew Induced Load Requirements	✓	See ICD	HRF	
3.3.8.1.2	6.1.1.5	3.1.1.5A	Safety-Critical Structures Requirements	✓	See ICD	HRF	
3.3.8.1.3	6.1.1.4C	3.1.1.4C	Modal Frequency	✓	See ICD	HRF	
3.3.8.1.4A	6.1.1.3A	3.1.1.3A	Launch and Landing Loads - Margins of Safety	✓	See ICD	HRF	
3.3.8.1.4B	6.1.1.3E	3.1.1.3E	Launch and Landing Loads - Random Vibration	✓	See ICD	HRF	
3.3.8.1.4C	6.1.1.3F	3.1.1.3F	Launch and Landing Loads - Load Factors	✓	See ICD	HRF	

✓ - Requirement is applicable   E - Exception   N/A - Requirement is not applicable

APPENDIX C

FUNCTIONAL PERFORMANCE VERIFICATION MATRIX

APPENDIX C

FUNCTIONAL PERFORMANCE VERIFICATION MATRIX

HRD Section	LS-71000 Section	Requirement	Applicable	Verification Method	Comments
3.2.1.1A		Functional Performance Characteristics	✓	A	
3.2.3B	7.3.1	Reliability, Quality, and Non-Conformance Reporting	✓	A	
3.2.3.C1	7.3.2.1	Reliability, Quality, and Non-Conformance Reporting	✓	A	
3.2.3.C2	7.3.2.2	Reliability, Quality, and Non-Conformance Reporting	✓	A	
3.2.3.C3	7.3.2.3	Reliability, Quality, and Non-Conformance Reporting	✓	A	
3.2.3.C4	7.3.2.4	Reliability, Quality, and Non-Conformance Reporting	N/A	N/A	No software
3.2.3.1		Failure Propagation	✓	A	
3.2.3.2	3.1.1, 7.2.1	Useful Life	✓	A	
3.2.3.2.1		Operational Life (Cycles)	✓	A	
3.2.3.2.2		Shelf Life	✓	A	
3.2.3.2.3		Limited Life	✓	A	
3.2.6.1		Launch and Landing	N/A	N/A	Launch and landing requirements directly imposed by SSP 57000.
3.2.7.2.11.1A		HRF MARES Rack Trip Requirements Summary	✓	A	
3.2.7.2.11.1B		HRF MARES Rack Trip Requirements Summary	✓	A	
3.2.7.2.11.1C		HRF MARES Rack Trip Requirements Summary	✓	A	
3.2.7.10.1		HRF MARES Rack to MARES Interface Requirements	✓	T, I, A	
3.3.1.1.1.1A		Russian Materials Usage Agreement	✓	A	
3.3.1.1.1.1B		Russian Materials Usage Agreement	✓	I	
3.3.1.9C		Locking Wires	✓	A	
3.3.3	7.3.1	Workmanship	✓	I	

✓ - Requirement is applicable E - Exception N/A - Requirement is not applicable T - Test
I - Inspection D - Demonstration A - Analysis

APPENDIX C

FUNCTIONAL PERFORMANCE VERIFICATION MATRIX (Cont'd)

HRD Section	LS-71000 Section	Requirement	Applicable	Verification Method	Comments
3.3.6.2.1A	6.4.3.5.1	Interior Color - Rack Mounted Equipment - Front Panel Color	✓	I	
3.3.6.2.1B	6.4.3.5.1	Interior Color - Rack Mounted Equipment - Front Panel Finish	✓	I	
3.3.6.2.1C	6.4.3.5.1	Interior Color - Rack Mounted Equipment - Latches	N/A	N/A	HRF MARES Rack is not rack mounted equipment
3.3.6.2.2A	6.4.3.5.2A	Interior Color - Stowed/Deployable Equipment - COTS	✓	I	
3.3.6.2.2B	6.4.3.5.2B	Interior Color - Stowed/Deployable Equipment - Repackaged	✓	I	
3.3.8.2.1	6.2.2.14	Batteries	N/A	N/A	HRF MARES Rack contains no batteries.

✓ - Requirement is applicable　　E - Exception　　N/A - Requirement is not applicable　　T - Test
I - Inspection　　D - Demonstration　　A - Analysis

APPENDIX D

ACCEPTANCE AND QUALIFICATION TEST APPLICABILITY MATRIX AND REQUIREMENTS

APPENDIX D

TABLE D-1. ACCEPTANCE AND QUALIFICATION TEST APPLICABILITY MATRIX

HRD Section	HRD Verification Section	LS-71000 Section	Requirement	Applicable	Comments
3.4.1A	4.3.1.1, 4.3.1.2	5.4.1.1.6.1 and 5.4.1.1.6.2	Thermal Environment Compatibility	✓	
3.4.1B	4.3.1.1, 4.3.1.2	5.4.1.1.6.1 and 5.4.1.1.6.2	Thermal Environment Compatibility	✓	
3.4.2	4.3.2		Vibration and Sine Sweep	✓	HRF will accept the risk of not performing acceptance vibration testing on the MARES Rack stowage drawer and the MARES Rack. No substitute verifica-tion method will be used to replace acceptance vibration testing for the MARES Rack stowage drawer and the MARES Rack.
3.4.3	4.3.3	5.4.1.3.4	Functional Acceptance	✓	
3.4.4	4.3.4	5.4.1.1.10	EEE Parts Burn-in	✓	
3.4.5	4.3.5	5.4.1.1.8	Flammability	✓	
3.4.6	4.3.6	5.4.1.1.9	Offgassing	✓	
3.4.7	4.3.7	5.4.1.1.4	Shock	N/A	Not rack mounted equipment
3.4.8	4.3.8	5.4.1.1.5	Bench Handling	✓	Drop test for PIP only
3.4.9	4.3.9	5.4.1.1.1	Payload Mass	✓	
3.4.10	4.3.10	5.4.1.2.1	Electromagnetic Compatibility	✓	
3.4.11	4.3.11	5.4.1.1.7	Acoustic Noise	N/A	
3.4.12.1	4.3.12.1	5.4.1.1.11.1	Safety-Critical Structure Dimensional Check	✓	
3.4.12.2	4.3.12.2	5.4.1.1.11.2	Safety-Critical Structure Material Certification	✓	
3.4.13	4.3.13	5.4.1.3.1	Software Acceptance	N/A	No software
3.4.14	4.3.14	5.4.1.3.2	Pre-Delivery Acceptance	✓	
3.4.15	4.3.15	5.4.1.3.3	Pre-Installation	✓	

TABLE D-2. NON-CRITICAL HARDWARE QUALIFICATION TEST REQUIREMENTS

Type Test \ Component	HRF MARES Rack Structure	PIP	Cables	Kits	Stowage Drawer
Thermal Cycling 7.5 Cycles	N/A	✓	N/A	N/A	N/A
Qualification for Acceptance Vibration	N/A	✓	N/A	N/A	N/A
Flammability	✓	✓	✓	✓	✓
Offgassing	✓	✓	✓	✓	✓
Bench Handling	N/A	✓	N/A	N/A	N/A
Payload Mass Control Plan	✓	✓	✓	✓	✓
EMI/EMC Control Plan	N/A	✓	✓	N/A	N/A
Acoustic Noise Control Plan	N/A	N/A	N/A	N/A	N/A
Sinusoidal Resonance Analysis	✓	N/A	N/A	N/A	✓

TABLE D-3. NON-CRITICAL HARDWARE ACCEPTANCE TEST REQUIREMENTS

Type Test \ Component	HRF MARES Rack Structure	PIP	Cables	Kits	Stowage Drawer
Thermal Cycling 1½ Cycles	N/A	✓	N/A	N/A	N/A
Acceptance Vibration	E	✓	N/A	N/A	E
Functional	✓	✓	✓	✓	✓
Burn-in	N/A	✓	N/A	N/A	N/A
Pre-Delivery Acceptance Functional	✓	✓	✓	✓	✓

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